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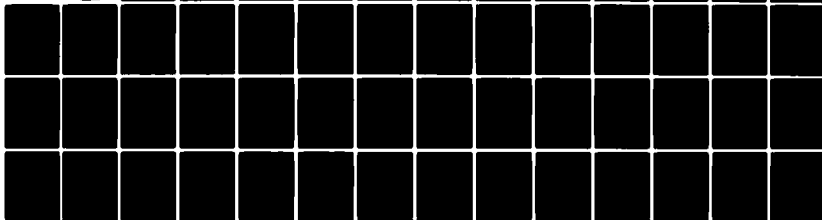
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Contributions to Industrial Development
of Science and Technology Institutions
in Colombia
and
Opportunities for Bilateral Cooperation

G. E. Schweitzer and P. Pinsky

December 1979

Final Report to U.S. Department of State

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CONTRIBUTIONS TO INDUSTRIAL DEVELOPMENT OF
SCIENCE AND TECHNOLOGY INSTITUTIONS IN COLOMBIA
AND
OPPORTUNITIES FOR BILATERAL COOPERATION •

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PREFACE

This report analyzes (a) the characteristics and capabilities of the principal institutions that comprise the science and technology infrastructure in Colombia, (b) the potential contributions of these institutions to industrial development, and (c) opportunities for bilateral cooperation between these institutions and related institutions in the United States. Two companion reports analyze similar activities in Nigeria and Malaysia. A fourth report presents a cross-country comparison of some of the principal findings in the three country reports. A final report describes the methodology used in carrying out the country studies.

The report is based largely on observations during a three-week visit to Colombia in June 1979 by a team of senior scientists and engineers from Cornell University and on documentation obtained during the visit. Despite the brevity of the visit, the team was able to gain a number of insights concerning the activities of research, educational, and industrial organizations in Colombia.

Figure 1 identifies those types of science and technology endeavors that are considered in the report. Particular attention is given to the interactions among these activities and to the linkages between these activities and the efforts of production organizations.

Figure 1 FUNCTIONS OF THE SCIENCE AND TECHNOLOGY INFRASTRUCTURE			
	Education & Training	Adaptation, Development & Research	S&T Services
PUBLIC AND PRIVATE SECTOR ACTIVITIES	Scientists and Engineers Skilled Labor Teachers Technicians Managers	Technology Choices Engineering Facilitation Design and Modification Development and Demonstration Basic and Applied Research	Information Extension Testing and Quality Control Maintenance and Repair Patents
INTERNATIONAL ASPECTS	Overseas Training Expatriate Instructors	Technology Transfer International Research Networks	Expatriate Advisors International Services

The emphasis is on science and technology activities which relate directly and indirectly to manufacturing; to the physical infrastructure needed to support industrial development including transportation, communication, power, and water systems; and to development of the natural resource base. Science and technology activities directed to medicine, public health, and nutrition are not considered. Similarly, the development and harvesting of food crops are beyond the scope of this study. However, the development and processing of non-food crops are considered to a limited degree.

Special appreciation is extended to the Colombian Foundation for Scientific Research (COLCIENCIAS) and many other Colombian organizations which assisted in the collection of much of the data presented in the report and provided insights as to the problems and opportunities in the application of science and technology in the country. Also, the assistance of the U.S. Embassy in Bogota, the U.S. Consulates in Cali and Medellin, and the Department of State in facilitating the study and providing helpful suggestions is gratefully acknowledged.

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EXECUTIVE SUMMARY

Colombia should be in a good position to use science and technology more intensively in efforts to reverse the decline in the international competitiveness of its manufactured products, expedite development of abundant natural resources, and provide improved services and job opportunities in rural areas. Colombia has a large pool of well trained manpower, at both the professional and blue collar levels, and considerable experience in the design and implementation of development programs involving modern technologies. In addition, a recent history of relative political stability and of an uninterrupted evolution of economic policies provides a framework for sustained growth. Foreign exchange reserves offer the option of using those international technologies which are best suited to the Colombian environment.

However, if Colombia is to benefit from many of the recent advances in science and technology, several significant changes in the institutional framework for technical activities seem imperative. First, Government agencies need a much strengthened technical capability to understand the direct and indirect implications of decisions involving technologies that are being made daily, and particularly decisions concerning foreign direct investment, international licenses, and Government procurement of goods and services. Secondly, major reforms of the over-extended university system are needed to restore a semblance of academic excellence within at least the better universities. No university can be expected to offer good programs in science and engineering when (a) most of the faculty members are part-time, with the turnover rate of full-time faculty averaging two to three years, and (b) admission standards have declined to the point where most of the entering students are unable to complete the programs. Related to the serious adverse effects on educational quality of the uncontrolled growth of universities is the lack of a manpower planning capability at a time when the supply of scientists and engineers is outracing the demand. Finally, more effective mechanisms for the horizontal diffusion of technologies within the country (e.g., strengthened professional societies, expanded role for trade associations, improved information systems) are sorely needed.

At the same time there are a number of very effective institutions which give considerable impetus to science and technology efforts. The Foundation for Scientific Research (COLCIENCIAS), while a newcomer among Government agencies, is gradually earning respect as a key focal point within the country for the development of a variety of scientific and technical policies and programs. Although underfunded and operating under a limited charter, the caliber of its staff and the quality of its surveys and reports command considerable respect. In the area of vocational training, Colombia has pioneered in the harnessing of the training capability of the private sector in preparing needed skilled manpower for the nation. SENA's on-the-job apprenticeship program at every firm, in particular, received praise from both industry and students. Related to training activities are the programs of technical assistance to small industry of several financial institutions, and particularly the Popular Finance Corporation, which couple financial and technical help in efforts to increase productivity. Finally, the strong capabilities in civil, electrical, and mechanical engineering of several local engineering consulting firms have provided the technical backbone for a variety of major development projects throughout the country.

Many of the larger manufacturing firms have been strengthening their scientific and engineering staffs in recent years. About a dozen locally owned firms have research and development facilities, and many more have quality control laboratories. These capabilities are important in the assessment and selection of foreign technologies and in the continuous process of minor and sometimes major modifications of production technologies that are already in place. Attention is frequently directed to adjusting the capital/labor mix and the mix of local/imported raw materials, and to reducing energy costs. A recent survey of one hundred firms reports an average expenditure of 0.5 percent of sales on design engineering and on process and product adaptation activities, with a subsequent correlation with productivity increases. This type of technological capability is central to the nation's efforts to increase the pace of industrialization.

The large exploration and development expenditures associated with current efforts of multinational firms to develop oil, gas, and mineral deposits dwarf all other research and development expenditures within the country. These efforts, which involve a large number of highly trained Colombians, should be coupled more closely to the development of related capabilities at educational and research institutions, and particularly institutions located in the areas of the country where the exploration and development activities are underway. Several multinational companies assemble motor vehicles in Colombia. Recent requirements for local manufacture of a portion of the components have resulted in increased technical capabilities of local suppliers. There are only a few examples of multinational firms effectively interacting with research and education institutions, and steps are needed by all interested parties to increase such interactions.

University research activities need stronger financial support and a clearer sense of direction. Research capabilities are particularly important as graduate programs begin to evolve. Also, they help attract and retain high quality faculty, and they provide a mechanism for directing considerable talent to problems of national importance. While Colombian universities cannot aspire to significant frontier research in the basic sciences, they should seek to develop strong capabilities in areas closely linked to the nation's resource endowments, especially in the geo- and bio-sciences. Pollution control and development of new energy sources are particularly appropriate areas for research at the engineering facilities. Finally, there are too many small research projects of little significance scattered throughout the universities. COLCIENCIAS should increase the size of its university research grants, which are often only several thousand dollars, and, if necessary, reduce the number of grants accordingly.

The Fulbright Program is the last vestige of a long tradition of U.S. Government support for significant bilateral science and technology exchanges with Colombia. Fortunately, the very successful program of the International Executive Service Corps has become self-sustaining in Colombia. The National Science Foundation has a mechanism for supporting joint research projects involving U.S. and Colombian university investigators, but this program is largely dormant. Even the occasional visitors from the National Bureau of Standards and the National Technical Information Service no longer include Colombia on their itineraries. The atrophy in bilateral linkages is particularly discernible at the Colombian universities where American scientists and engineers are now rare sights and where attendance at technical meetings in the United States is no longer seriously considered. This lack of interaction is undoubtedly one factor in the decline in emphasis on the English language at the universities.

At the same time, as the capabilities of Colombian universities and research institutions increase, the opportunities for technical exchanges of interest to U.S. specialists increase. The principal need is for a funding mechanism which will enable U.S. specialists to spend short periods of time (1-3 months) and longer (1-2 years) visits at Colombian institutions. Also, support for attendance by Colombian specialists at technical meetings in the United States and for a program of sabbatical visits to U.S. universities could be very helpful. Finally, U.S. Government support of a few sustained linkages between Colombian institutions and U.S. universities in fields such as petroleum engineering, mining technology, food sciences, and oceanography should be of substantial interest and benefit to both countries.

THE COUNTRY SETTING

Prospects for National Development

Colombia has considerable potential for economic growth. Substantial natural resources, a large pool of skilled workers at both the professional and blue collar levels, and considerable experience in the planning and execution of development programs provide an optimistic outlook for national development. In the near-term, the improving access to energy and mineral resources and the continuing increase in the world price for coffee will undoubtedly boost Colombia's position as a significant Latin American country.

Relative political stability and minimally disruptive transitions of power during administrative changes have characterized Colombia in recent years. Consistent economic policies which have been designed to support strongly industrial development have resulted in a growth rate of over eight percent per year. The average per capita income of \$675 per year is not high. However, the low unemployment rate of eight percent, the increasing rate of literacy, and the expansion of social services are positive development indicators. Figure 2 presents some of the indicators of social and economic development.

Figure 2			
ECONOMIC AND SOCIAL INDICATORS			
GNP per capita (1977)	\$720	Production Growth Rates (1970-77)	
Annual Growth (1960-77)	2.7%	GDP	6.4%
Rate of Inflation (1970-77)	21.4%	Industry	5.9%
Population (1977)	25 M	Manufacturing	7.5%
Growth Rate (1970-77)	2.1%	Distribution of Value Added (1975)	
Urban (1975)	66 %	Food and Agriculture	33%
Adult Literacy (1975)	81 %	Textiles & Clothing	18%
Life Expectancy (1977)	62	Machinery and Transport	10%
Labor Force (1977)		Chemicals	12%
Percentage of Population	59 %	Other Manufacturing	27%
Growth Rate (1970-77)	3.5%	Annual Energy Growth Rates (1974-76)	
In Agriculture	31 %	Production	-2.4%
In Industry	23 %	Consumption	3.6%
In Service Sector	46 %	Trade	
		Exports/Imports (1977)	\$2.3/1.5B
		Growth Rates (1970-77)	1.2/- .8%
Source: <u>World Development Report 1979</u> , The World Bank, August 1979			

Colombia is a prominent member of the Andean Pact which influences the nation's position in both the regional and global environments. Andean Pact membership is viewed by some as insurance against variability of world market supply and demand. Others consider the Andean Pact as a political and economic counterweight to the growing influence of the larger Latin American countries. In any event, many Colombian leaders believe that the Andean Pact has already resulted in tangible economic benefits for Colombia.

Imbalances in National Development

The manufacturing urban sector has grown more rapidly than the agricultural rural sector in terms of both production and income. The economic imbalances are particularly apparent when income from coffee products is extracted from the agricultural statistics. Still, some progress is being made, and the real income in rural areas is increasing although not as fast as income in urban areas.

Meanwhile, the problem of urban migration continues to plague Colombia, with about 66 percent of the population now classified as urban. The principal urban centers are bulging despite Government programs to improve life in the countryside through better educational opportunities, improved social services, and jobs associated with transportation and public works projects. Incentives include technical and financial assistance to farmers and rural communities and prohibitions on industrial expansion in some urban areas. However, the stream of youth to the towns and cities has not been abated.

Income distribution inequalities exist in varying degrees among regions, reflecting unbalanced geographical development--between the industrially advanced central region which includes Bogota, Cali, Medellin, and Bucaramanga; the agricultural areas of the Llanos; and the northern coastal area frequently characterized by disabling climatic conditions.

Despite these imbalances, overall economic progress in Colombia has been impressive during the past several decades. Modern cities symbolize the nation's capability to modernize through the marshalling of its technical and resource base. Also, an increasing proportion of the rural population is being brought into the mainstream of the economy, albeit slowly. However, a particularly vexing problem currently facing the nation that further aggravates regional and social disparities is inflation. Inflation has exceeded 20 percent and has even been reported to have reached 30 percent.

Industrial Development

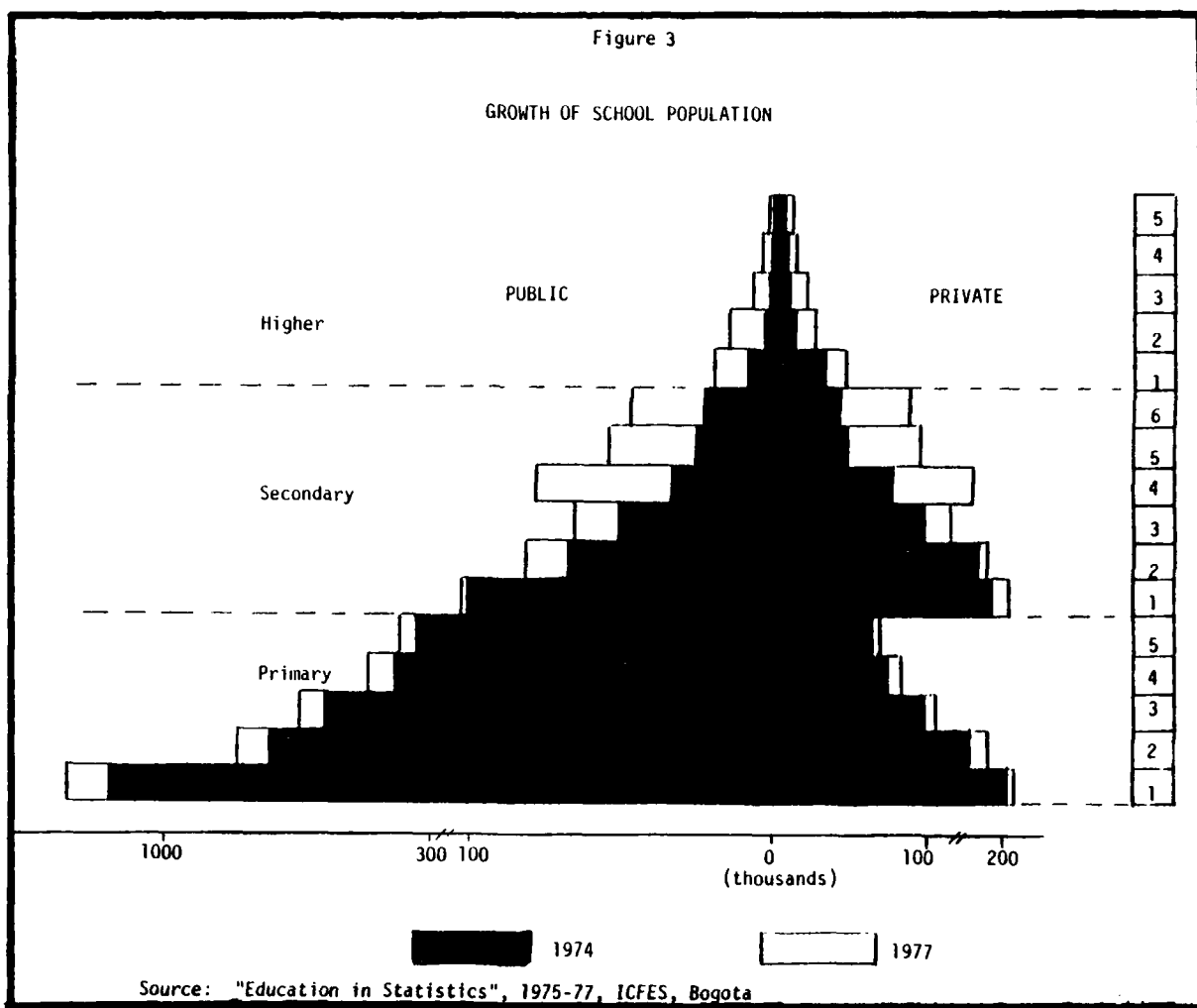
Diversification of export products, assistance to small and medium industry, and greatly expanded resource exploration are three of the keys to the current industrialization strategy. In the past, industrial policies were frequently directed to encouraging import substitution efforts of the larger firms (e.g., over 200 employees). However, protectionist policies to achieve a greater degree of industrial self-sufficiency are now considered to have reduced the motivation of local entrepreneurs in seeking internationally competitive technologies. Also, there is a growing belief that the large firms can take care of themselves. Thus, attempts to improve export opportunities, through a combination of increased competitive pressures and Government incentives to upgrade the productivity of many types of firms, dominate much of the discussion of future industrial strategies. Indeed, assistance to small and medium industry is big business among both private and public sector organizations in Colombia, with foreign experts playing a much reduced role in such efforts.

Coffee exports provide much of the income needed for sustaining the industrialization drive. In addition, Colombia is endowed with a wide range of other natural resources: hydro power, oil, coal, natural gas, emeralds, forests, and limited quantities of iron ore, nickel, and phosphates. In the past, rugged geography has seriously inhibited resource extraction, but this problem is being overcome slowly. Increasing costs of

energy, in particular, have resulted in the introduction of a range of technologies which will help open up relatively inaccessible areas for resource development.

Growth of the Education Sector

The zeal for education is strong. By the mid-1970's school enrollment had reflected a sixfold increase over enrollment in 1960. Colombia has boasted of a higher percentage allocation of its national budget to education than any other Latin American country. Expenditures for education nearly equal expenditures for all other social services combined. Figure 3 depicts the growth of the school population during the past several years.



The education system has been reformed and much improved in recent years, particularly at the primary and secondary levels. Conventionally, the educational path includes basic primary education, secondary education through middle school, and several forms of higher education. Vocational and academic training are available at a number of public and private institutions.

Regional difference and rural-urban differences have caused some problems, particularly as students migrate to take advantage of educational opportunities in different parts of the country. However, increasing enrollments at all levels indicate progress in promoting a truly national effort. Literacy rates have risen significantly as would be expected.

The recurrent political upheaval at the universities, and particularly at Nacional University in Bogota, are highly disruptive and severely retard efforts to upgrade the faculty and curriculum. In addition, these disruptions have increased the traditional reluctance of industry to rely on universities for research and technical support. Although unlikely to stop completely, political demonstrations appear to be less frequent than in the past and increasingly less tolerated by administrators.

Many serious problems as to the quality of education have resulted from the very rapid expansion of universities in recent years. There has been a very discernible decline in admission standards and student performance requirements at even the best universities. Such a trend will not be reversed in the near future in view of the weak preparation at many of the secondary schools, the excessive course loads for instructors, and the inadequacies of many of the laboratories and related facilities to accommodate the large student influxes.

Trade and Technology Ties with the United States

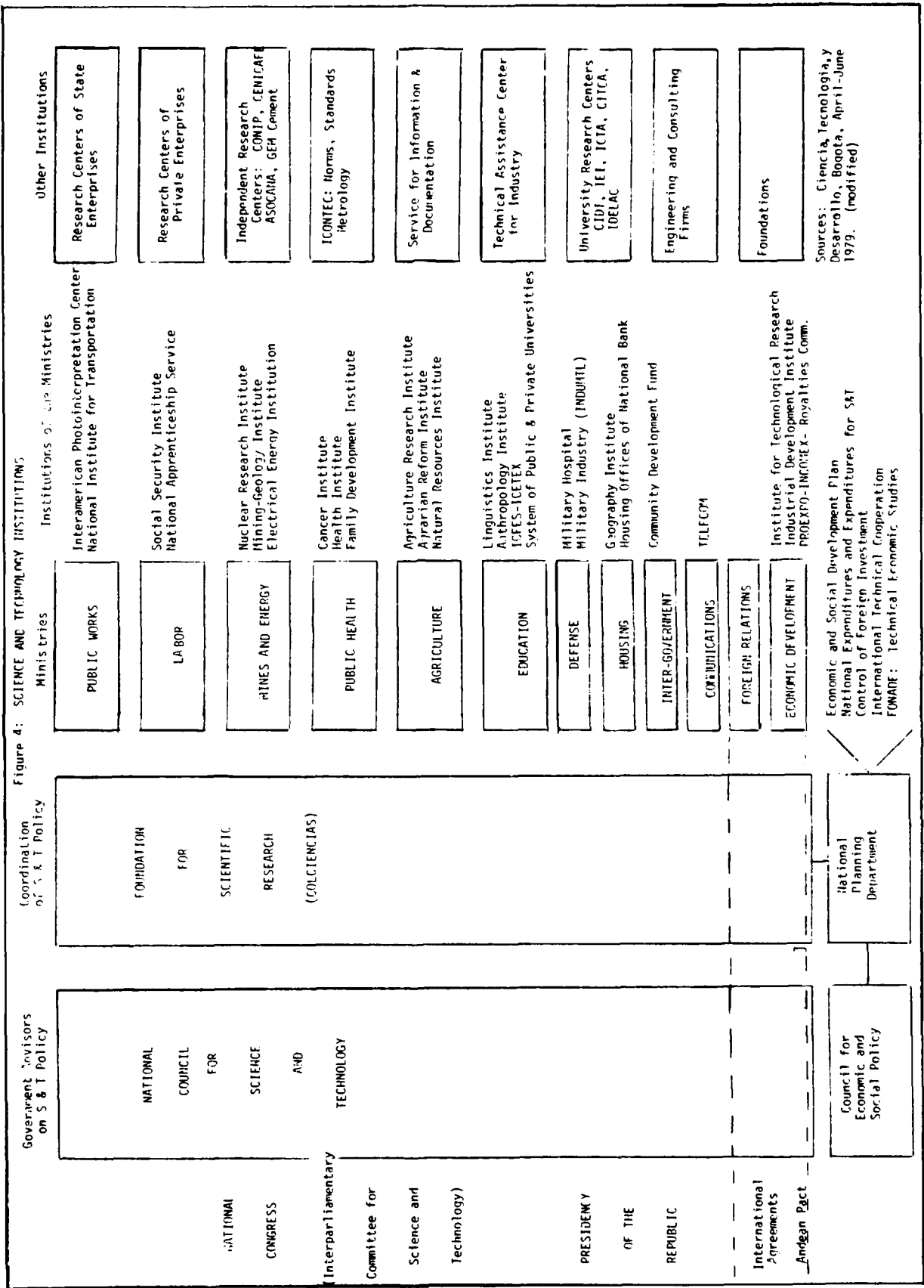
The United States is Colombia's most important trading partner, accounting for more than 40 percent of Colombia's coffee trade and more than 50 percent of the trade in other agricultural products. Coffee in turn accounts for two-thirds of export revenues with total foreign exchange holdings having reached \$2.3 billion in 1978. Over 30 percent of Colombia's imports are from the United States. Colombia's trade within the Andean Common Market and the Latin American Free Trade Association is limited but growing steadily.

Despite the current emphasis on export industries, the international competitiveness of non-traditional products has declined in recent years. The new five-year plan to be released in late 1979 is expected to reveal some policy modifications directed to improving the levels of Colombian production technology and industrial productivity. Specifically, such modifications might call for the gradual reductions of selected tariffs, improved procedures for access to foreign technologies, and joint efforts by Government and industry in technology assessment and choice.

The integration and foreign trade policies of the Andean Pact affect technological development, directly and indirectly. For example, provisions concern national product specialization and development, regional and international tariff policies, limitations on foreign direct investment, and restrictions on licensing and royalty fees. Indeed, the flow of technology has been a major concern of the Andean Pact.

Considerable political controversy focuses on the effects of Andean Pact policies on the flow of technology to Colombia. Some multinational firms argue that prohibitions on licensing agreements between parent and subsidiary firms and on capitalization of technology have inhibited upgrading and innovation in existing facilities and investments in new facilities. Other companies have adjusted readily to the current investment regulations. The Colombian leadership apparently believes that market competition between foreign sources of technology will propel the technology transfer process under these regulations.

Scientific and technological ties with the United States are strong. U.S. investment in Colombia is substantial. U.S. construction, product, and industrial standards are an important component of the Colombian scene. Products made in the United States and local replicas of U.S. products are everywhere to be seen. About 3,000 Colombian students are enrolled in universities and colleges in the United States, and graduates of leading U.S. educational institutions can be found in almost every Colombian institution of any size. Many Colombian scientists and engineers live in the United States while retaining strong ties in Colombia. In short, the American influence is apparent throughout the country, and anti-American rhetoric is seldom encountered at the personal level. Conditions are indeed favorable for the further strengthening of ties between the U.S. and Colombian science and technology communities.

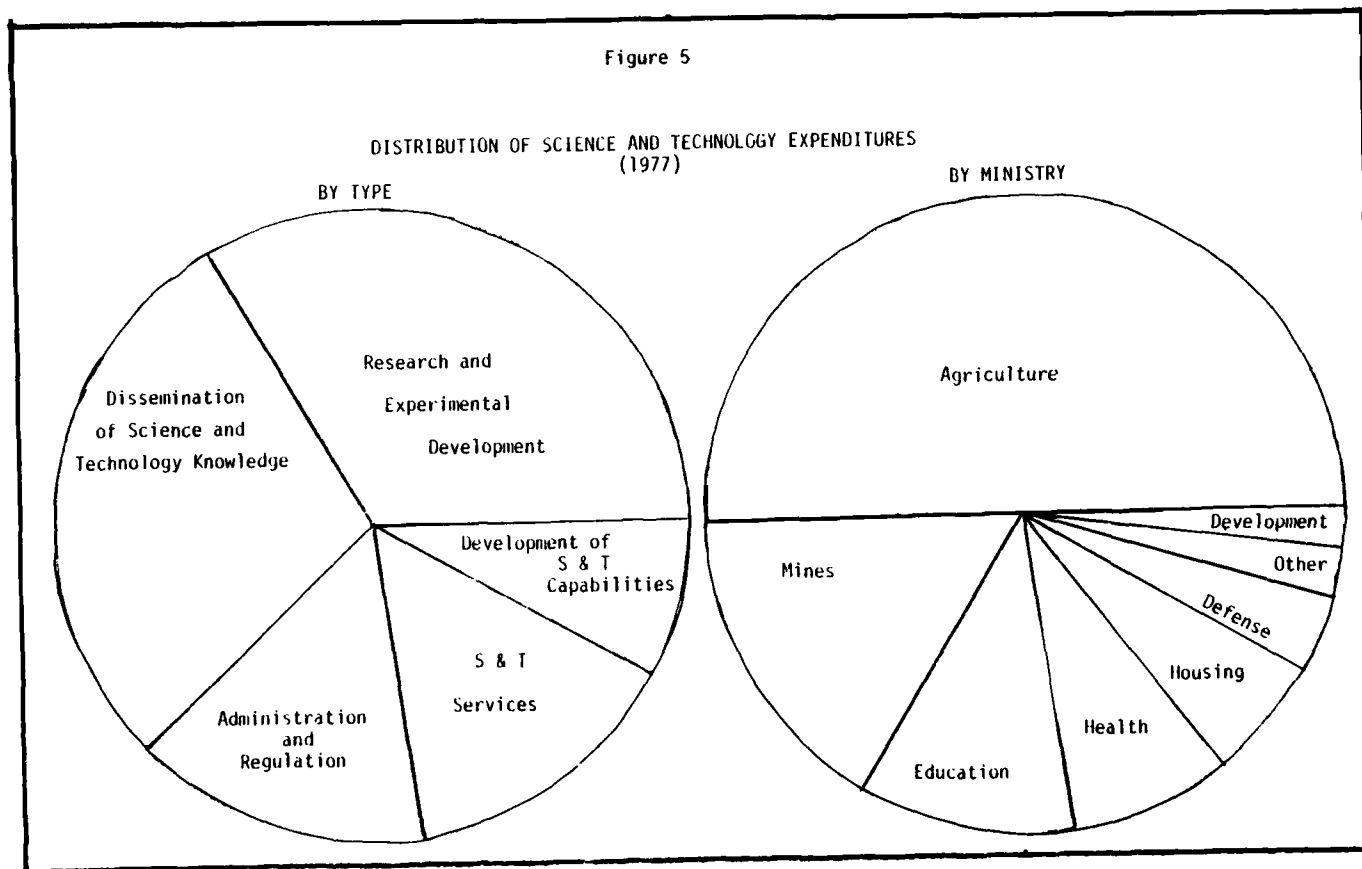


THE INSTITUTIONAL FRAMEWORK FOR SCIENCE AND TECHNOLOGY

The Range of Science and Technology Institutions

Government agencies, industry, and other organizations in Colombia are investing sizeable resources in the development of science and technology capabilities throughout the country, convinced that these investments will contribute to the economic and social development of the country. In the near term, principal attention is on preparation of the technical manpower that can choose and use effectively a wide range of technologies from abroad. For some years, the technology transfer process has been characterized by a continuing series of minor engineering modifications and occasional major adjustments in imported technologies. Now there is particular concern whether the basic technologies that are being employed are the most appropriate and whether modifications are taking full advantage of the raw materials of the country and the opportunities for adding value locally. In the longer term, current investments in manpower and facilities are expected to increase the indigenous component of technologies that are used in Colombia through employment of the products of local research and development activities.

As indicated in Figure 4, many public and private organizations are involved in some aspect of science and technology. Figure 5 describes the national budget for science and technology. The institutions which are involved vary considerably in their capabilities and technical orientation.



For example, of the 75 or more universities currently in place, only a handful are capable of providing high quality undergraduate educations in the sciences or engineering. Several of the industrial laboratories could be characterized as research laboratories, but most of them confine their activities to quality control and routine testing. Some public institutions such as ECOPETROL-- the organization responsible for the development of the nation's petroleum resources-- have very strong technical staffs while the technical departments of some of the ministries are not comparably staffed.

An interesting feature of the Colombian scene is the large number of analytical groups with strong capabilities in policy areas involving science and technology. In the private sector, for example, the Foundation for Higher Education in Cali, the SER Research Institute, and FEDOSAROLLO (the "Brookings Institution" of Colombia) conduct a variety of studies on issues of near-term importance to the Government, and it seems likely that these independent assessments command an interested audience throughout the country.

Conspicuously absent are strong professional societies which can serve as meeting grounds for technical specialists working on related problems in different types of institutions around the country. Most of the professional meetings that are held are confined to local areas. A broader approach to foster professional ties could be an important aspect of encouraging the internal diffusion of scientific and technological knowledge.

National Policy Organizations

As in most developing countries, the Planning Department and the Ministry of Finance play key roles in the formulation of policies and budgets that influence many aspects of science and technology. The Planning Department is particularly influential in Colombia because of the high quality of economists that have traditionally been associated with that organization.

A number of agencies have responsibilities in the area of technology transfer, leading to some confusion as to procedures and uncertainty as to policies. The Planning Department approves all foreign direct investment. The Foreign Trade Agency, INCOMEX, approves all import requests. The Global Licensing Committee reviews for INCOMEX "packages" of imports to support large industrial operations. The Royalty Committee reviews all licensing arrangements. The Central Bank approves all technical assistance arrangements in the private sector. Should Government capital be involved in the technology transfer arrangements, the Industrial Development Institute (IFI) may play a role.

In the education and training area, the Ministry of Education and the Ministry of Labor have the principal policy responsibilities at the national level. Other ministries which have specialized manpower needs may also support training programs, and of course the states play a key role at the local level.

The Ministry of Education has delegated much of the responsibility for the planning and accreditation of higher educational institutions to The Institute for the Development of Higher Education (ICFES). This institution was established many years ago with the assistance of the Ford Foundation and now plays a decisive role in determining the future direction of higher education in the country.

Also reporting to the Ministry is the Institute for Financing Education and Technical Training Abroad (ICETEX). Originally established to administer international educational exchange programs, which have always been an important dimension of Colombian educational efforts, ICETEX now also administers a program of scholarships at educational institutions within Colombia.

A third agency reporting to the Ministry of Education is the Foundation for Scientific Research (COLCIENCIAS) which was established in the early 1970s to promote scientific research at several Government research institutes and at the universities. Its formal responsibilities include:

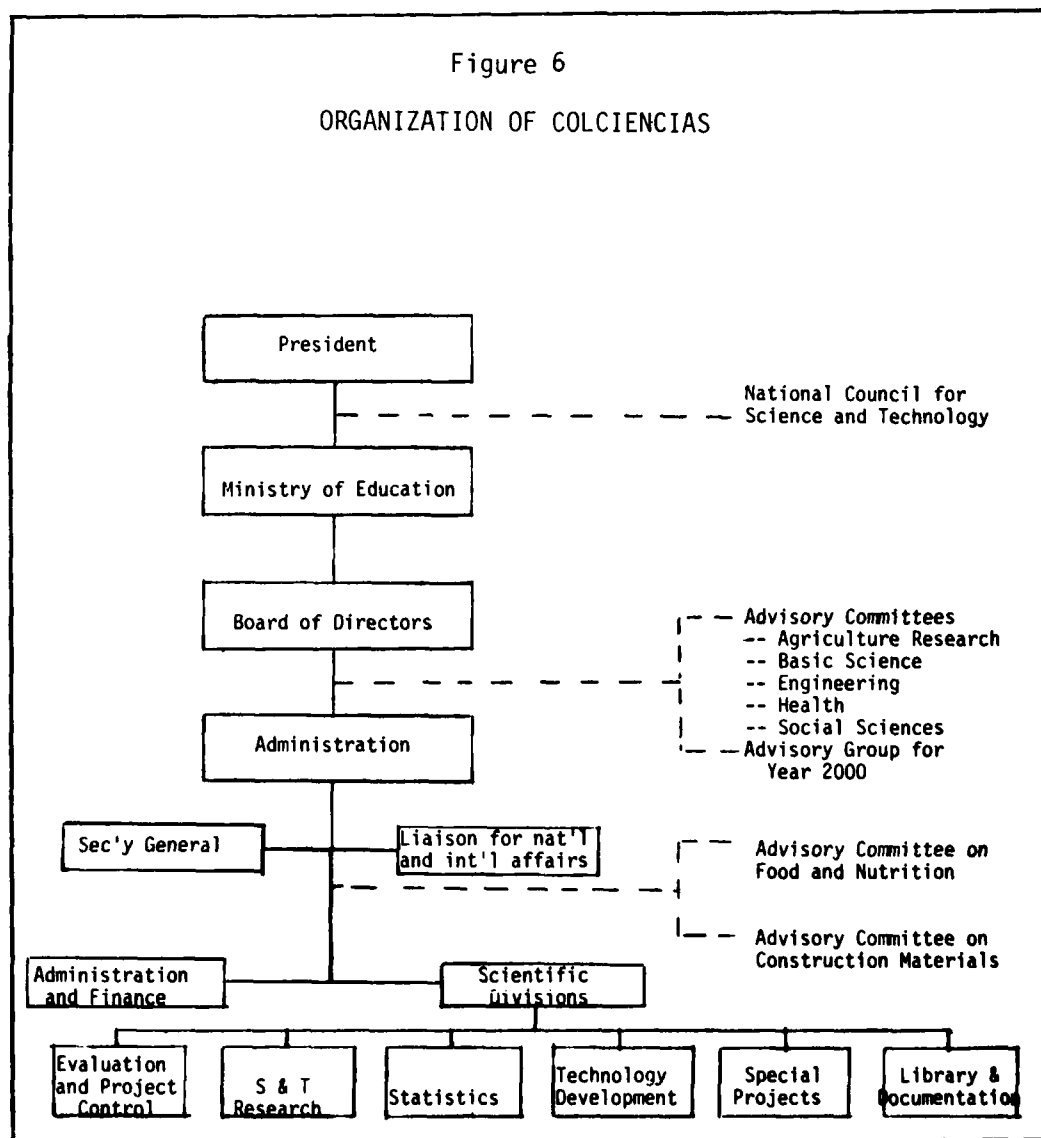
- to facilitate the financing of plans, programs and projects pertaining to science and technology, principally research-oriented programs;
- to provide the coordinating link between research programs in the public and private sectors;
- to maintain a current inventory of existing resources pertaining to the field of science and technology in the country;
- to establish and maintain an effective information network to disseminate research results and other relevant materials;
- to help sponsor Colombian delegates to international symposia on science and technology, as well as assist them in study and preparation for their participation in the conference;
- to procure increased funds from the public and private sectors, on national and international levels, for the development of science and technology;
- to finance and manage Government sponsored projects related to educational and scientific development;
- to establish financial and honorary incentives for research and publications concerning research.

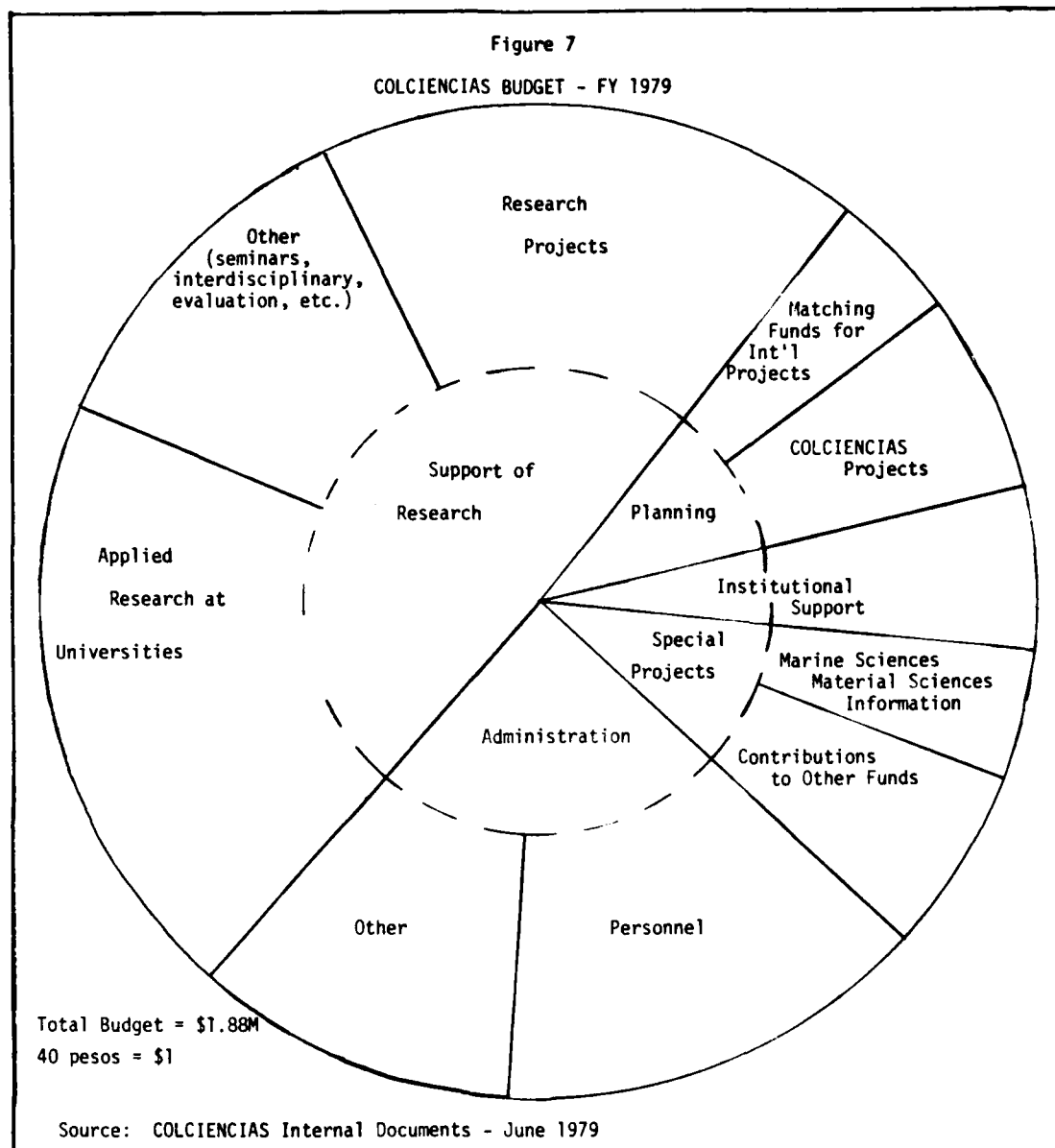
Within the Ministry of Labor, the specialized agency SENA was established explicitly for the purpose of improving the skilled manpower pool throughout the country and now has a range of formal and informal training programs. However, there is some uncertainty as to the relationship of SENA activities to the activities of the Ministry of Education. More recently, the Ministry has established a new technology unit concerned with promoting labor-intensive technology.

Many other ministries are also responsible for important technological programs. The Ministry of Economic Development plays a central role in determining industrial development paths, and through IFI and the Popular Finance Corporation, provides important financial support for selected activities. The ministries responsible for developing components of the physical infrastructure determine the priorities and specifications of major projects and set the policies governing the selection of contractors and the general character of their approaches. As an example of a regional activity, the CVC corporation in Cali has often been compared to the TVA although their objectives and activities are somewhat different.

The Effectiveness of COLCIENCIAS

COLCIENCIAS has slowly but surely established its credentials as an important policy and program body within the Colombian Government. The leadership of the organization has survived two changes of Government, and its programs have continued without disruption and with steadily increasing financial support. Figure 6 outlines the current COLCIENCIAS organization. Figure 7 describes the COLCIENCIAS budget.





COLCIENCIAS has been operating under three severe handicaps. First, it is subordinate to the Ministry of Education which is not an influential body in affecting policies and programs of other Government agencies responsible for the development of the nation's capabilities in health, agriculture, and industry. Secondly, it is a latecomer on the scene where other Government agencies have traditionally resisted the influences of outside organizations. Finally, its charter is rather narrowly drawn, and it could be interpreted as restraining the organization from becoming significantly involved in the applications of science and technology.

Despite these handicaps COLCIENCIAS is making its presence felt. Of greatest importance, COLCIENCIAS has attracted and retained very talented individuals to staff positions. Secondly, the organization has compiled and

published important information as to the current state of Government and university science and technology activities to buttress arguments concerning the need for coordination and neglected areas. Finally, COLCIENCIAS has strong international ties, including ties with international development agencies which fund projects of interest to many Colombian organizations.

Still, COLCIENCIAS has a long road ahead in its efforts to improve the application of science and technology to development of Colombia. Only recently has the organization been invited to participate in interagency discussions of specific technology transfer proposals, and in most cases COLCIENCIAS is informed of Governmental decisions on technological choices after the fact. The inventorying of industrial research activities throughout the country is just beginning, and critical assessments of the quality of Government research and development activities have not yet been attempted. While the organization has made a good start in focusing Government attention more sharply on critical issues in science and technology, additional high quality analytical work of a more controversial nature will be essential in the years ahead.

Perhaps the most important area requiring intensified COLCIENCIAS attention is the agency's extra-mural research program. While more than 700 research projects have been funded in recent years at a cost of \$3 million to COLCIENCIAS, the payoff from the programs can and will be questioned. Specifically, there appear to be some unrealistic expectations as to how Government research institutes and universities can impact on industry. Research projects carried out in universities in particular should not be oversold as providing near-term solutions to commercial problems. Also, many of the research projects are pitifully small--with COLCIENCIAS funding often limited to a few thousand dollars. Such funding levels are hardly likely to result in meaningful research results, nor are they sufficient to attract and retain high quality researchers who have competing job offers from private industry. Consideration should be given to increasing the size of research grants, and, if necessary, reducing the number of grants. In any event, the total size of the COLCIENCIAS external research budget is very small, and a good bellwether of the significance of the agency on the local scene will be the growth of this budget in the years ahead.

The Importance of Institutional Linkages

The Planning Department and COLCIENCIAS are the essential organizational mechanisms for providing a greater degree of coherence to many uncoordinated and often conflicting policies among the agencies at the national and state levels involved in science and technology. Many of the problems have been recognized, and over time the coordination and effectiveness of complementary programs should improve.

Coordination of Government policies and programs with the activities and interests of the private sector is another story, and few effective mechanisms for strengthening the linkages between public and private organizations concerned with industrial development exist. At the top of the priority list is the need for more effective approaches to the assessment of foreign technologies of interest to industry that will also be scrutinized by Government. Over the years a number of approaches have been attempted including the establishment of Government research institutes, the establishment of public/private technical associations (e.g., plastics, metallurgy), and most recently the establishment of public/private research institutions directed to upgrading local technological approaches (e.g., sugar, forestry). The Planning Department is keenly aware of the need for stronger capabilities

to assess foreign technologies in areas such as textiles and metal working and recognizes that such assessments must be carried out by or for those entrepreneurs interested in acquiring the technologies. How this capability is also to be linked to the Government agencies involved in the approval process is the problem.

The universities and industry do not interact effectively despite the large number of part-time instructors at the universities from industry and the continuing competition among industrial firms for the best graduates of university science and engineering departments. Industry generally considers university activities to be somewhat abstract and divorced from the real problems of production while the university faculties are usually so busy with routine course work that they have little time to concern themselves with industrial activities. In several cases, such as at the Santander Industrial University, specialized units have been established to provide research and related service for industry. While these activities have been helpful for the small entrepreneurs, they seem to be of little interest to the larger firms. Greater exposure to industry at the universities, perhaps through lecture series and joint reports on research activities, should be feasible in many cases. In addition, greater industrial representation on university advisory groups could increase interactions.

In a few cases industry has taken the initiative to draw on the technical capabilities of the universities. One area of particular interest has been the measurement and control of environmental pollution. In some cases, the universities have the best local analytical chemistry facilities for measuring pollution; and industries, usually with the prodding of local Government authorities, have asked the universities for help. There are instances of firms donating equipment to the universities; sometimes the equipment is excellent, but on other occasions it has not been helpful and has even been inoperative. In one case, a company is planning to establish an endowed chair within an engineering department.

The vocational training programs of SENA are well coupled to industry. A two percent payroll tax levied against all firms supports the SENA programs, including the apprenticeship program which requires each firm to devote five percent of its workforce to SENA apprentices serving in two-year training programs. At the completion of the training, most of the apprentices are employed by the same firm. In addition, industry frequently hires the graduates of SENA vocational schools. There are some complaints from small firms that the program benefits primarily the larger companies but in general the program is well received by industry.

Of special concern have been the linkages between the multinational companies (MNCs) and local industry. Clearly there have always been commercial and technical ties between the MNCs and their suppliers and customers. Now, with the advent of requirements for local manufacture of a percentage of the components for items assembled in Colombia, these technical ties are being strengthened. The MNCs are becoming far more interested in the quality control procedures used by their suppliers, and in many instances have launched major programs to upgrade the technological capabilities of these local firms.

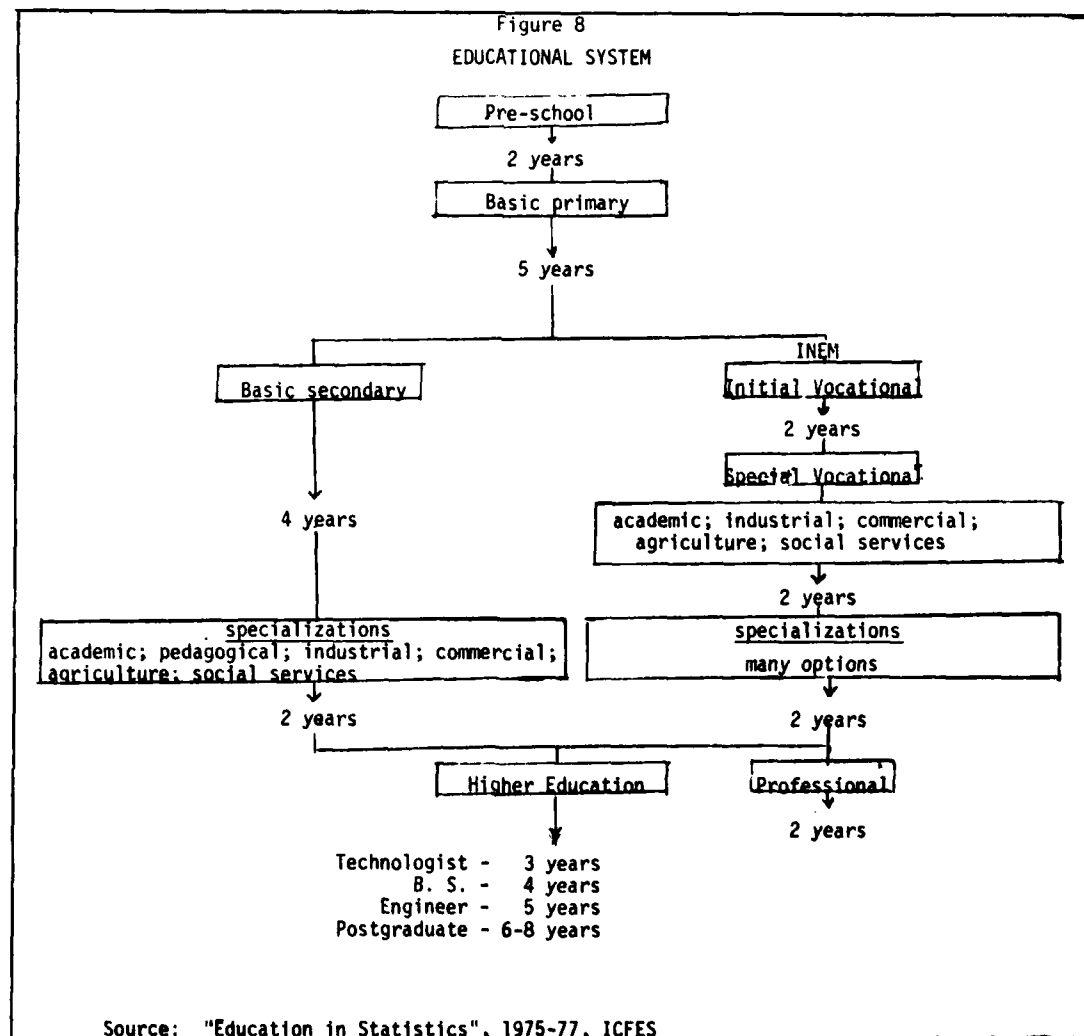
In addition to the need for strong professional societies previously noted, a number of trade organizations in Colombia should be in a position to assist

in improving interactions among industrial and other groups interested in science and technology. Chambers of Commerce and ANDI have helped bring industrial interests closer to Government on several aspects of technology transfer. Another type of effort might be to attempt to keep industry abreast of the problems and opportunities confronting the engineering and technical schools.

EDUCATION AND TRAINING CAPABILITIES

Overview

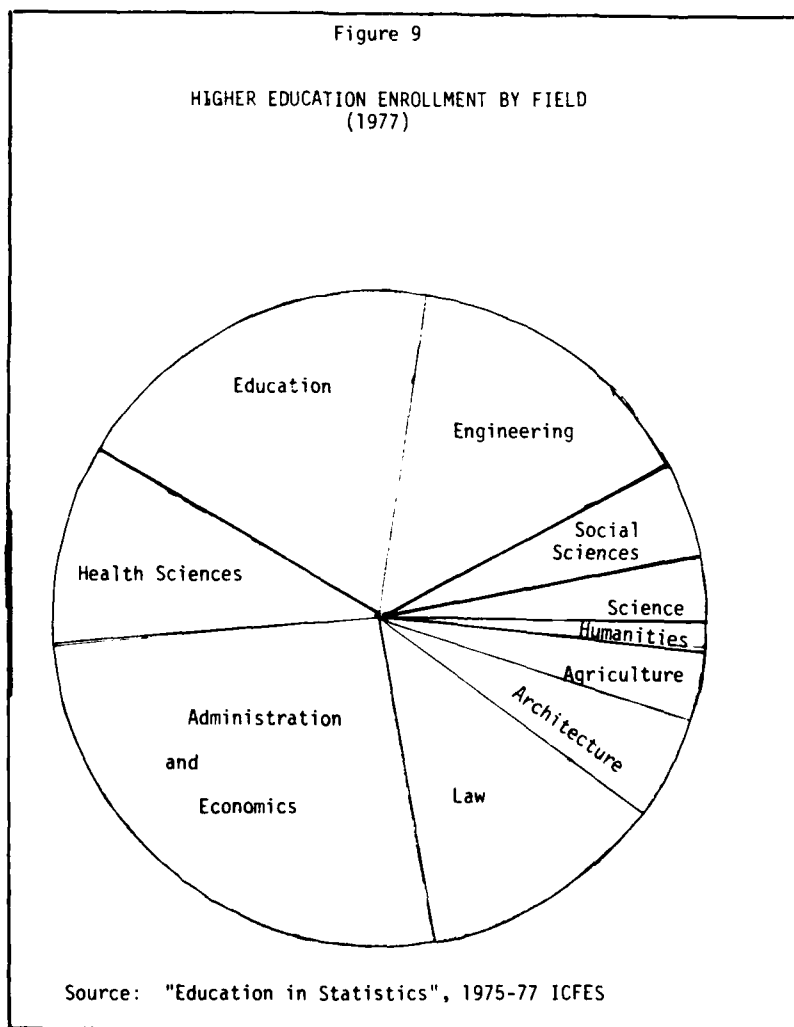
As shown in Figure 8, after five years of primary education, pupils ordinarily enroll in a four-year secondary program. Secondary education is achieved either through the traditional school programs, which include vocational options as well as academic preparation, or through the Institutes of Diversified Intermediate Education (INEM), which are specifically oriented to the development of technical and vocational skills. Following either of these programs the pupils then have the further option of enrolling for two additional years of training. Higher education refers to all education and training following successful completion of secondary curriculum. A technical degree can be awarded after three years of study at a polytechnical institute, a bachelor's degree after four years at a university, a professional degree after five or six years at a university (engineer, doctor, lawyer), and a master's-equivalent degree after two or three additional years. The Ph.D. is not awarded in science or engineering at the present time. About five percent of the primary school enrollees enter institutions of higher education. Of these about 40 percent receive degrees, although the dropout rate in science and engineering is higher.



As expected, the highest percentage of students enrolled in programs of higher education are concentrated in the urban areas. In view of these regional disparities, the Government has established as a national objective the strengthening of educational opportunities in the rural areas.

At present there are more than 75 universities, including many recently established private universities of questionable capabilities, and about 20 polytechnical institutes, including a large number located on university campuses. Only a few of the universities stand out as strong centers of excellence in the physical and engineering sciences, and only two or three of the polytechnical institutes are recognized as offering solid technical educations. The history of political disruptions at the public universities has had a devastating impact on the attitudes of many students toward academic responsibilities at many institutions--homework is not given a high priority, and examinations are not taken seriously. Many parents have therefore sought enrollment for their children at private institutions, which explains in part the rapid proliferation of universities.

The growth of enrollment in higher education is impressive, having risen from 85,000 in 1970 to over 237,000 in 1977. There has been a very slow growth in the percentage of students enrolled in the physical and natural sciences. On the other hand, enrollment in engineering has dropped from 23 percent in 1963 to 15 percent in 1977. (See Figure 9).



The Colombian system distinguishes between full-time, part-time, and lecture responsibilities among faculty members. Considerably less than 50 percent of the faculty members are employed as full time. Almost 50 percent are employed solely as lecturers, usually on a part-time basis, with no student or research responsibilities. Many instructors hold appointments at several institutions.

With regard to vocational training there are 19 institutes within the INEM system and over 100 vocational schools within the conventional school system. In addition, 18 National Service Centers are operated by SENA, and of course many multinational and locally owned firms offer a range of specialized training programs for their employees.

This growth rate in education, particularly at the university level, has already resulted in a serious underemployment problem, particularly among engineers. Also, there has been a decline in educational standards which is readily acknowledged by Government officials, university faculties, employers, and students. Special purpose higher educational institutions (e.g., a school for civil engineers) have appeared throughout the country in response to the pressures from all sectors of society for education of the youth as a passport to a better life.

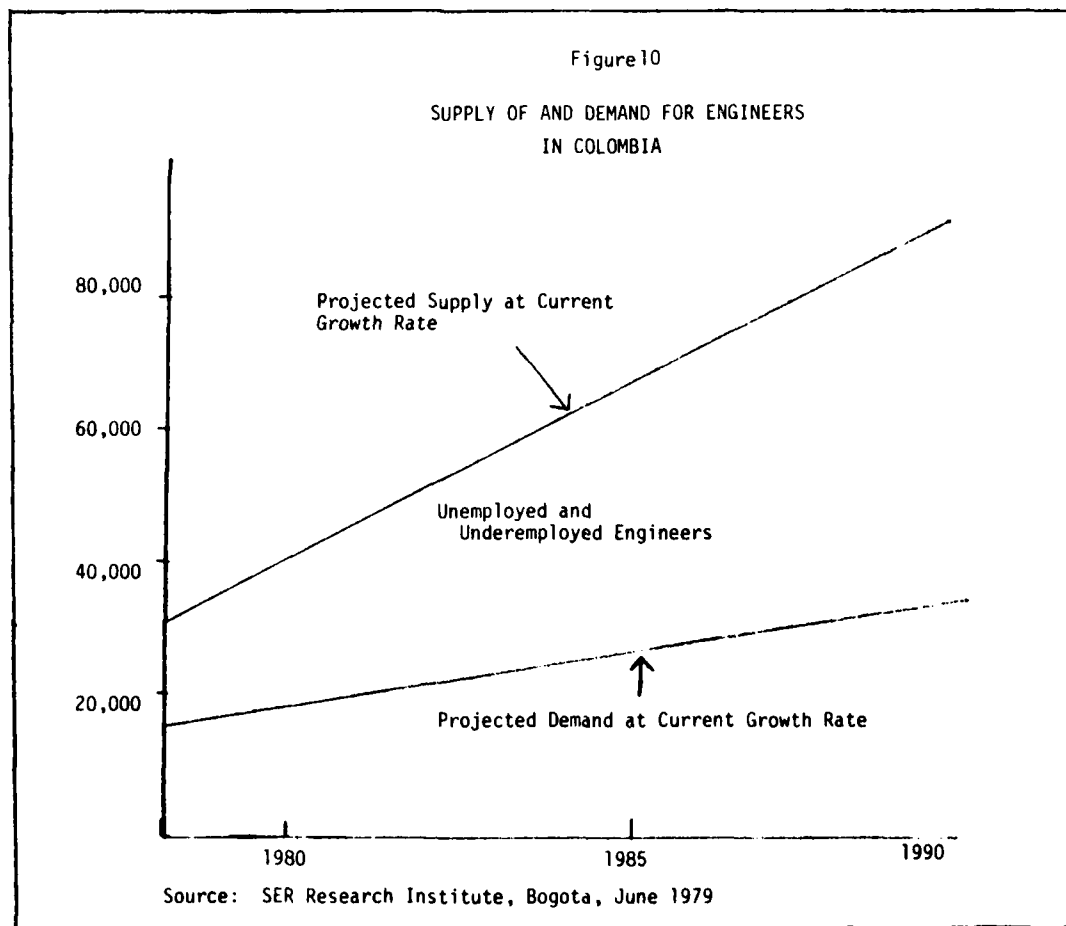
Criticisms of the educational system from within Colombia are quite sharp. Studies prepared for COLCIENCIAS and FES, for example, have identified the following problem areas (Ciencia, Tecnologia, y Desarrollo, Volume 3, No. 2, p. 167):

1. Lack of pecuniary incentives and other professional benefits to attract and retain competent professors at universities and other training institutions.
2. Lack of integrated, challenging science programs.
3. Lack of physical facilities and lack of financial and staff capabilities to attend and/or arrange meetings, seminars, and symposia on science and technology issues, either inside or outside Colombia.
4. Lack of recognition and status for research and for investigators at universities.
5. Inadequate documentation centers and library services. Although many of the standard textbooks and international science journals are available to students, large new university libraries frequently have closed stacks, few books, and limited checkout privileges because of fear of theft. Also, often local reports and journals are not widely distributed.
6. Faulty maintenance of laboratory and scientific equipment.
7. Lack of outside consultants and collaborators to assist university personnel in research projects, referring to the absence of solid institutional linkages between universities and local industry and other economic activity.
8. Greater emphasis on professional counseling for students than on conducting research activities.

9. The lack of a serious applied research atmosphere on campuses which could stimulate and coordinate student research with professional development.
10. Lack of funds for research at universities.
11. Lack of curriculum standardization and quality control of specific degree programs in science and technology fields.

Manpower Planning

Colombian officials have become painfully conscious of the disequilibrium between technical manpower supply and demand. Recently initiated efforts to assess the supply of and demand for engineers and skilled workers are long overdue. As illustrated in Figure 10, underemployment of engineers is severe and growing worse. While the number of engineers in Colombia is expected to double every six years, the demand for engineers is estimated to double every ten years. Currently, the SER Research Institute estimates that of the current supply of 32,000 engineers, only 50 percent are employed as engineers. Other manpower projections are being conducted at the present time by SENA, ICFES, UNESCO, and the Dutch Government. Better coordination of these projects would help improve their utility. Also, in 1974, COLCIENCIAS published a study outlining manpower demands in the mining and energy sector which could provide a good comparative basis for current studies.



One of the problems confronting educational planners is the unpredictable migration of engineers and technical specialists to Venezuela. Another problem is the variance in quality of trained engineers and the absence of national standards for engineering and technical training programs and certification. While many of the engineering graduates apparently are not able to find engineering jobs, graduates of the better schools and graduates in particular fields have a much easier employment search.

The lack of a clear national policy or even an understanding as to the role of universities and polytechnical institutes in the development of Colombian society is a basic planning problem. Further, the Government has not exercised effective control over the educational growth patterns and has made only minimal attempts to gather relevant information on manpower needs and utilization. Also, there is a general feeling as to the futility of planning within the system which needs to be eliminated quickly.

As a first step, a Government agency should be given clear responsibility for the continuing assessment of manpower supply and demand. The most logical choice would seem to be the Planning Department which could then draw on other agencies and on private sector institutions to help carry out needed analyses. The Planning Department is in a good position to relate such analytical efforts to the policy and program decisions that are made throughout the Government that affect manpower trends. Also of importance is the regular publication of available projections which can be of assistance to the educational community in planning expansions or modifications of existing programs and to students who are confronted with career choices.

Graduate Education

The entire area of graduate education in science and engineering, and indeed in other fields as well, is in a state of disarray. There are no national standards or policies in this area, and each university determines its own approach.

Figure 11	
GRADUATE PROGRAMS IN SCIENCE AND ENGINEERING	
<u>Institution</u>	<u>Fields</u>
Javeriana	Biology, Microbiology
Santander	Physics, Chemical Engineering, Metallurgical Engineering
Los Andes	Mathematics, Systems Engineering
Nacional (Bogota)	Systems Engineering
Cauca	Civil Engineering
Photointerpretation Center	Photointerpretation for Civil Engineering and Geology, Remote Sensing for Forestry
EAFIT	Applied Mathematics
Source: <u>Postgraduate Programs and Courses in Colombia,</u> ICETEX, 1978	

As shown in Figure 11, graduate programs are offered in eleven science and engineering disciplines at selected universities. Some of these programs are continuing education programs and offer certificates after a few months of study. A few are designed to produce M.S. graduates, but none offer doctoral programs. In some cases research is carried out by the students as part of the M.S. degree requirements, but the pattern is inconsistent. There are no accreditation procedures.

ICFES has become aware of the many inconsistencies throughout the country in graduate education and is attempting to formulate an approach to the problems in this area. Among the issues that should be explored are:

1. What is the likely demand for advanced degree holders and how can this demand be stimulated?
2. Should centers of excellence in different disciplines be encouraged?
3. What constitutes legitimate graduate education?
4. What is the optimal rate of growth of graduate programs in the various disciplines?
5. What are the foreign language requirements for advanced degrees in science and engineering?

There are considerable pressures to expand graduate programs, particularly from faculty members with Ph.D.s earned abroad who see graduate programs as the primary vehicle for enabling them to pursue their research interests. Further, COLCIENCIAS research grants have had a stimulating effect on involving graduate students in research activities.

At the same time, the facilities and equipment needed to start graduate programs can be expensive, and the demand for graduates with advanced degrees does not appear great. Therefore, a continuation of reliance on graduate degree programs abroad as the general rule seems desirable. At the same time, a gradual introduction at selected universities of graduate programs of high quality should be encouraged.

Undergraduate University Education

Most of the full-time faculty members at even the best university science and engineering departments are young, relatively inexperienced, and generally overloaded with course work, which may reach twenty-five contact hours per week. Typically, the faculty member will have an M.S. degree from a good U.S. university. The annual turnover rate among faculty members ranges from 15 to 40 percent, as industrial salaries are strong attractions for many of the most promising young engineers and to a lesser degree the young scientists. Thus, it is not surprising that there is not a strong sense of commitment to the teaching profession among many of the faculty members.

Fortunately, at each of the universities there are also a few senior faculty members with Ph.D.s, usually from good U.S. universities, who are committed to the academic life and who provide the continuity and stability which allows the universities to function. They design the courses and orchestrate the continuing influx of part-time faculty and individual course lecturers. The quality of the senior professors varies, but in general they seem to provide the basis for reasonably good educational experiences at the better universities. As seen in Figure 12, only a handful of universities offer courses in the sciences

other than the medical sciences. Usually, the larger universities will be strong in only one or several departments. In engineering, more than 40 universities offer courses in one or more of 27 engineering disciplines. Different universities emphasize different fields (e.g., civil, electrical, mechanical) even though they may offer courses in other fields as well. The strengths of the universities are directly related to the capabilities of the senior professors, including those who become the deans -- capabilities to design and present good programs and capabilities to raise the necessary funds to equip laboratories and related facilities.

Figure 12

UNDERGRADUATE SCIENCE PROGRAMS

University	Biology	Marine Biology	Marine Sciences	Physics	Geology	Mathematics	Oceanography	Chemistry
Nacional (Bogota)	X		X	X	X			X
Nacional (Medellin)						X		
Antioquia	X		X		X	X		X
Valle	X		X		X	X		X
Javeriana	X					X		
Andes	X		X		X			
Fundacion Lozano		X	X				X	
Naval Academy							X	
Santander								X

Source: ICFES, June 1979

During the past ten years, the physical structures that house some of the universities have improved enormously. The buildings financed by large loans provided by the Inter-American Development Bank in particular are quite impressive. Still, the enrollments have outgrown the facility expansions, and overcrowding has not subsided but probably has grown worse.

The laboratories used for teaching range from very good to primitive. Again, strong departments have good facilities, while the weaker departments

at the same universities have poor facilities. The laboratories at Nacional University in Bogota are considered to be the best. Teaching laboratories at some of the universities are integrated with research laboratories which underscores the importance of a steady evolution of graduate education capabilities at selected universities within the country.

The quality of the students at the universities is highly variable. Admission standards have been lowered, particularly at the public universities, and this trend has also influenced admission policies at the private universities. Thus, it is not surprising that dropout rates at the science and engineering faculties at the better universities frequently reach 60-70 percent. Some of the dropouts transfer to easier courses while others simply leave school. Even some of the graduates become quite skeptical of their technical abilities and look for administrative and service jobs rather than technical employment upon graduation.

The material covered in the classroom at the engineering faculties compares favorably with coursework at U.S. universities. However, the laboratory experiences are spotty, depending on the experience of the particular instructor and the availability of equipment.

With the rapid expansion of the student enrollment, there has been a decline in the capability of the students to use the English language. Since many of the available books that are important sources for students are in English, this decline in English competency is surely having an impact on the material that can be covered. Even at Los Andes University, which for many years prided itself on its students' mastery of English, fluency in English is no longer considered to be particularly important.

The Polytechnical Institutes

The role of the polytechnical institutes is not clear, even to senior Government officials. These institutes currently provide technical and engineering courses at a sub-university level, but the demand for the types of skills that are being developed is questionable. With several exceptions, the quality of the programs is considered marginal at best, and attracting and retaining high quality faculty is a major problem. Most of the best graduates apparently attempt to continue their educations by enrolling in the engineering faculties of the universities, particularly in those cases when the polytechnical institutes are located on university campuses.

The minimum curriculum requirements for these three-year institutes are:

1. The curriculum be designed to train the student in specific technical skills for particular professions;
2. At least 50 percent of the curriculum be conducted outside the classroom, in practical training;
3. 30 percent of the curriculum be devoted to basic sciences (mathematics, physics, chemistry, biology);
4. 50 percent of the curriculum be oriented toward training in specific technologies;

5. 10 percent of the curriculum be devoted to complementary technologies;
6. 5 percent of the curriculum be devoted to general humanistic and cultural studies.

The Role of the Foundation for Higher Education

The Foundation for Higher Education (FES) is a private non-profit organization, which was established by civic and business leaders in Cali and is currently financed at about \$4 million per year, principally by interest from its own investments. FES is dedicated to improving higher education and to promoting collaboration between the private and public sector to this end.

FES finances a variety of studies on the education system, provides consulting services to universities which are attempting to raise funds for various purposes, and sponsors seminars on topics of interest to both the universities and the business community. It also funds selected research projects at the universities and helps improve the availability of books and information services for faculty and students.

Such an independent capability to critically examine university development is somewhat unique in developing countries. FES should continue to play an important role in complementing the efforts of the Government to improve the educational system.

Overseas Training

Tens of thousands of Colombians have received their undergraduate or graduate educations in the United States, with a large proportion having graduated in scientific or engineering disciplines. There are presently about 3,000 Colombians studying in this country. Most of the graduates of U.S. institutions have returned to Colombia although during the past two decades an estimated 10,000 or more have become permanent U.S. residents. Some of these Colombians have chosen to remain in the United States because of the lack of opportunity to carry out research and other types of technical activities in Colombia. A number of these emigres retain close ties in Colombia and return to that country frequently.

Colombian dependence on training in the United States seems to be declining, particularly with regard to students sponsored by the two Governments. This change in emphasis has resulted partially from the increased educational opportunities in Colombia, a curtailment of the AID program which had previously supported many of the students in the United States, and increasing exchange programs with other countries including a number of Eastern and Western European countries.

Colombian officials and students are well aware of the capabilities of many U.S. universities and colleges, and they are in a good position to match student interests and capabilities with educational institutions in the United States. There is, of course, a continuing concern over admission to the better U.S. schools and a desire to establish exchange arrangements that could facilitate admissions. However, in general, the problems associated with Colombian students obtaining science and engineering educations in the United States are not serious, and stronger intervention by the U.S. Government does not appear necessary.

As previously noted, ICETEX was established as an agency to facilitate and in many cases finance student exchanges. In 1978 ICETEX provided loans for 250 students in the United States and 250 students in other countries. It also provides fellowships for 12 percent of the Colombian students studying at local universities. Recently ICETEX began supporting students at secondary schools. This organization is staffed by experienced professionals in the field of education and has received many accolades as an effective organization.

Skilled Manpower Development

The SENA program of the Ministry of Labor and the program of the Ministry of Education form the core of the Government's education and training programs to provide technical training for immediate employment purposes. While questions have been raised as to overlap and administrative duplication involved in these two programs, strengthening rather than reorganizing the programs should probably receive priority.

The SENA program employs 4,000 people and is the recipient of praise from all sectors of Colombian society -- the students, the employers, Government officials, and the providers of the funds. Its apprenticeship program, in particular, whereby five percent of the employees of every enterprise are SENA trainees has been heralded as an imaginative technique for harnessing the training capability of the private sector. The national training centers of SENA which are located throughout the country provide specialized training skills in areas such as aviation mechanics. SENA also offers programs to prepare adults for technical jobs and to upgrade the skills of currently employed technicians.

Small and medium industry do not react as enthusiastically to SENA programs as the larger companies, claiming large industry exerts more effective pressure on SENA to develop programs to match their needs at the expense of smaller industry. SENA officials believe that the real problem is lack of information and poor marketing to small and medium industrialists. As a result, SENA centers have planned to hire field representatives to inform managers of the relatively low costs and potential benefits of the program. With regard to SENA management training activities, future success depends heavily on high quality personnel recruitment by SENA, which has been difficult in the past due to more attractive salaries in the private sector.

SENA suffers high rates of turnover of staff, about 15 percent annually for both instructors and consultants. "Braindrain" of SENA staff and graduates to Venezuela is a problem at all levels of the program. Also, the program suffers from weaknesses of the economic system to effectively absorb the high quantity of trained technicians.

In spite of these difficulties, SENA remains a highly respected program, both on a national and international level. Trainees are usually able to find employment without difficulty. International support has been continuous since SENA's organization. Germany, France, England, and Holland have provided the most consistent funding, while the UN agencies such as UNDP and FAO have also contributed to SENA.

The INEM program offers both academic and vocational training and includes 19 training centers which roughly correspond to comprehensive vocational high schools in the United States. Unlike SENA students, INEM students are required

to pay for their training. The time required for an INEM degree is six years: the first two are spent in the classroom. The third and fourth in practical vocational training, and the fifth and sixth specializing in a particular technical aspect of the chosen trade. At the end of the program, the graduate has two choices: to seek immediate employment or to enter an institution of higher education.

The enrollment in INEM programs has quadrupled in the last eight years, and the number of INEM instructors has increased fivefold over the same period. Many of the same criticisms lodged against SENA have been noted about INEM. The principal ones are the high attrition rate among instructors and poor quality laboratory machinery and equipment, often less modern than that of SENA. Finally, the vocational placement problems plague INEM administrators.

Because of the heavy emphasis on SENA programs, the additional training activities of multinational and locally owned firms are frequently overlooked. Indeed, most of the larger companies appear to have incorporated the SENA apprenticeship requirements as an integral part of their overall approach to employee training. Still, there are substantial additional requirements for training at all levels both for new and for old employees. Also, increasing attention is being given to assisting in the training of employees of suppliers and customers as requirements for local manufacture of components which were previously imported increase and as the opportunities for introducing more sophisticated products into the marketplace expand.

Figure 13

TECHNOLOGY INTERESTS OF COLOMBIAN MANUFACTURERS

Firm (Industry)	Commercial Activities	Foreign Sources of Technology	Technological Characteristics and Needs
1. <u>Carvajal</u> (Annual sales: \$44 million; \$7 million in exports)	Produces printed material; potentially competitive in international markets	Technical managers from Germany and other European countries for short-term trouble-shooting. Technicians trained abroad.	Difficulties with royalty payments and import permits for rotary presses. Wishes to conduct research for new product lines and production techniques.
2. <u>Carton de Colombia</u> (Annual sales: \$70 million; \$16 million in exports)	Forest management, pulp, paper, packaging materials.	65% controlled subsidiary of Container Corporation of America; Foreign technicians in R&D.	Unique technology to process hardwoods; reforestation program. Need for cooperation with public authorities to develop new production techniques.
3. <u>Casa Schnaps</u>	Processed tobacco, pre-cut lumber, brushes.	Tobacco operation from US firm, lumber drying techniques from UK, treatment of saws and brush manufacture from Germany.	Wants to fund visits from foreign technicians, and observe foreign technology in brush manufacturing and cigar making.
4. <u>Cooperchena</u> (Annual sales: \$7.8 million)	Dairy Products	Milk powder technology from US, pasteurizers from UK, bottle cappers from UK, pasteurizer from E. Germany.	Equipment from Nestle subsidiary; firm is only competitive when milk is in high demand season; wants to expand milk powder production and establish cream plant.
5. <u>Duncan Industrial</u> (Annual sales: Under \$500,000; \$60,000 in exports)	Metal fasteners	Licensing agreement with US firm; Director is US-trained with US experience; toured French factories.	Many manufactured items US-designed; electronic safety lock being designed by US engineer. Needs foreign visits, funds for licensing agreements and for design of new product lines.
6. <u>Everfic</u> (Annual sales: \$7 million; \$2 million in exports)	Textiles, men's appare-- integrated operation from spinning machines to clothing manufacturers.	Equipment suppliers from Europe, UK, US visits to European factories, international fairs. European technicians on contract to set up machine maintenance systems.	Traditional manufacturing techniques from foreign sources. Need for loans to train technicians abroad.
7. <u>FUNDENTE</u>	Components for heavy mechanical equipment in metals.	Advised by Japanese technicians on lighter components for automotive industry.	Traditional line of technology. Need for visits by foreign technicians to advise on product expansion and for visits overseas to arrange new licensing.
8. <u>Industrias Emilic</u> (Annual sales: \$27 million; \$650,000 in exports)	Zipper manufacturer	Two owners trained in US 8-step zipper manufacturing reduced to 7 steps. Visits to foreign zipper manufacturers and suppliers help to maintain technological parity.	Heart of operation is tool and die making for zipper style variations. No current technological needs-- much of zipper equipment designed by Yndi.
9. <u>IMUSA Industries Metalurgicas Unidas</u> (Annual sales: \$2.8M exports insignificant)	Aluminum and plastic houseware goods.	German technical director since '35. Spanish technician 1941-45 on plastic manufacture. License from US company for electric frying pans. Technician trained in Austria; production technology derived from European, US equipment suppliers.	Standard technology. Need to finance visits of foreign technical advisors, and for R&D team in plastic products design and quality control.
10. <u>Industria Saccione de Repuestos</u> (Annual sales: \$3.3 million; exports insignificant)	Automotive parts, 30% sold to auto assembly industries.	Licensing agreements with 3-4 US firms, who provide technology package.	Technologically dependent on foreign licensing sources. Not much interest in moving into more competitive foreign market.
11. <u>Innersoll-Apolo</u> (Annual sales: \$6 million; \$2 million in exports)	Manufactures agricultural implements, pumping and hydrant equipment, spring brackets, brake drums.	Licenses obtained from US and UK for agricultural equipment, brake drums. Negotiating with German firm for new hose valve connections. Some technology from US and Swiss equipment suppliers.	Standard technology. Want to expand laboratory quality control, materials testing, and to design new products.
12. <u>Industria Ceramica Colombiana</u> (Annual sales: \$5.5 million; \$180,000 exported to Puerto Rico)	Porcelain, dinnerware.	Design and manufacturing knowledge from US license; visits by technicians to Europe, US, Argentina, Brazil. Input of know-how from equipment suppliers in Europe, US.	Standard manufacturing techniques. Want to explore German, Italian technology sources to improve design, dye materials; want new equipment for improved technology control.
13. <u>Compania Rinuso</u> (Annual sales: \$23 million)	Chemical and metal products (inks, paints, mixing tanks, etc.)	Original know-how in chemical area from Grace & Co., 10-15 year period no foreign licensing. Current licensing with UK firm for inks. Technicians sent abroad for short-term training.	Standard technology from foreign sources. Want funds for lab equipment in order to design their own chemical products.
14. <u>SPZ</u>	Meat Products for Colombian market.	German and Swiss technicians on meat manufacture. US specialists on packing techniques, distribution systems. Technical assistance from US equipment and material suppliers.	Standard technology. Wants to explore Caribbean export market; wants to meet upgrading requirements (technical); wants funds for technical advisors, visits to sources of upgraded technology.
15. <u>SIMSA</u> (Annual sales: \$14 million; \$1.2 in exports)	Foundry and rolling mill. Makes steel billets, angles, shapes.	Contract with Brazilian steel foundry to help select equipment, train technicians. Steel extrusion technology from US since '60. License with Canadian firm for alloys to supply Andean market.	Developed own technology for chrome carbon steel balls. Want to expand into low-carbon and alloy steels; want to fund design and engineering teams to develop new steel products.
16. <u>UNIA-- Union Industrial y Astilleros</u>	Manufactures heavy mechanical equipment--boilers, commercial vessels, hydroelectric dam gates, food processing equipment.	Licenses from US, Spain, France, Canada. Sub-contractors to US firms.	Venture with Canadian firm to design, engineer line of fishing and commercial vessels.

Source: Report prepared for Department of State by Developing World Industry and Technology, 1978.

CAPABILITIES IN ADAPTATION, DEVELOPMENT, AND RESEARCH

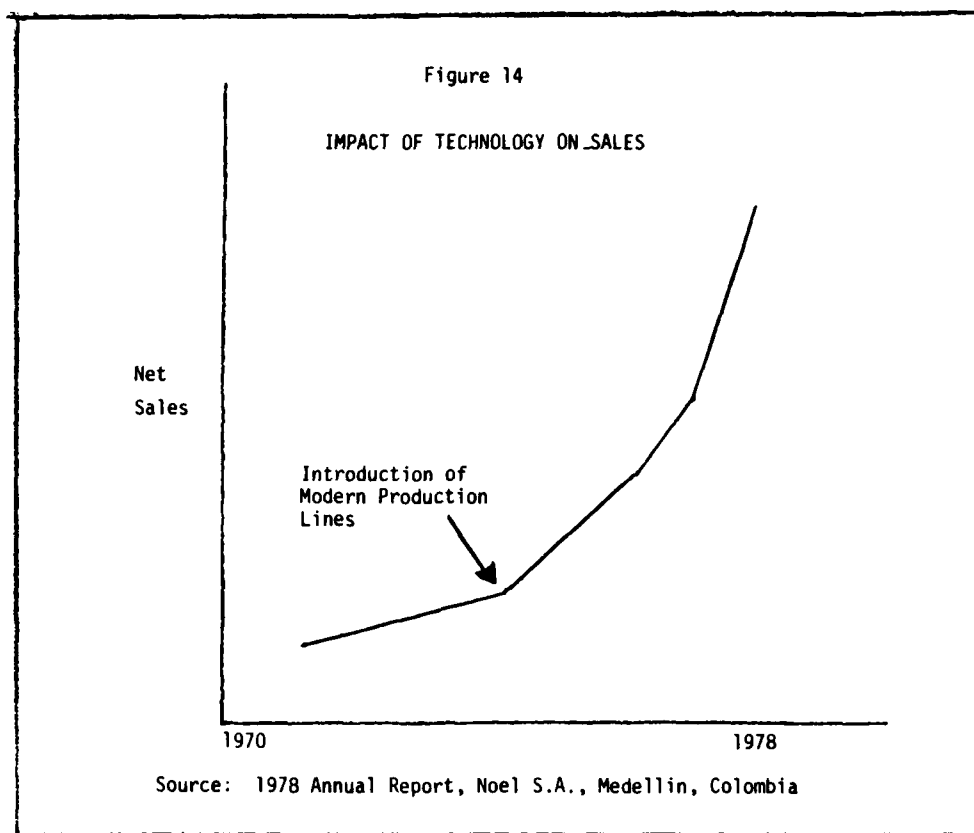
Technology Trends

Most of the basic technologies currently employed in Colombia have been imported or are a reproduction of technology developed abroad. This reliance on foreign technology will undoubtedly persist in the years ahead. In the longer term, Colombian officials are hopeful that through a combination of careful regulation of imported technology and a concurrent strengthening of the technical capabilities of local firms and of the supporting technological institutions, a greater degree of technological self reliance will emerge.

Already Colombia exhibits a considerable degree of autonomy in the selection of technologies that are to be used. The technical staffs of many of the larger firms are aware of technologies available around the world in their particular areas of interest, and they are capable of making wise technological decisions. However, the Government agencies are not equally confident in the technical basis for their decisions that affect the introduction of technologies which should be best suited to Colombian conditions. For example, IFI has abolished its technology staff despite its continuing involvement in high risk projects involving foreign technology. Similarly, small industry is generally not aware of the technological options for upgrading the quality of their products and for increasing productivity. Even when they know the types of technologies that would be most appropriate for their needs, they are uncertain as to the intermediate steps between current production practices and full utilization of such technologies. Thus, it is not surprising that the issue of improved capabilities for assessing and choosing technologies is a high priority item for the Planning Department.

The technology used throughout much of the industry reflects a continuing process of acquisition of foreign technologies followed by a series of minor modifications, and occasional major changes, over the years to adjust the technologies to particular Colombian requirements, with special attention to the most desirable labor/capital mix, imported/local raw materials mix, maintenance concerns, and energy costs. The changes are particularly noticeable in the ancillary and supporting operations surrounding the core process (e.g., loading, finishing, packaging). Figure 13 gives an indication of the sources of technologies used at a number of industrial facilities in the country and reflects the hybrid nature of technology that is now commonplace throughout the country.

Figure 14 dramatically reflects the benefits derived by one of the nation's leading food companies from the wise choice and installation of modern production lines based on foreign technology. The technology involves a combination of equipment from several countries adapted to Colombian conditions. In addition to increased profits for the entrepreneur, employment opportunities at the plant and among suppliers of the firm and distributors of the products have increased, and an improved product is reaching more customers throughout the country. A number of bankrupt companies attest to the penalties associated with the poor selection of technology. A well known example of such poor selection is the metal working firm, Forjas. In the 1960s Forjas purchased equipment from abroad to produce outdated tractor treads which had no market. The company has been in receivership since the early 1970s.



As previously noted, a number of Government agencies are involved in the regulation of industrial investments and of technology transfer arrangements. Figure 15 summarizes the types of licensing arrangement approved during a recent period. Figure 16 categorizes the reasons why a number of licensing applications have been denied. Despite the extensive reviews of the economic merits of licensing applications, however, political factors often override all other arguments in decisions on major projects. For example, the recent Government decision to approve production of metal containers rather than plastic containers for beer was inevitably influenced by the political orientation of the interested parties.

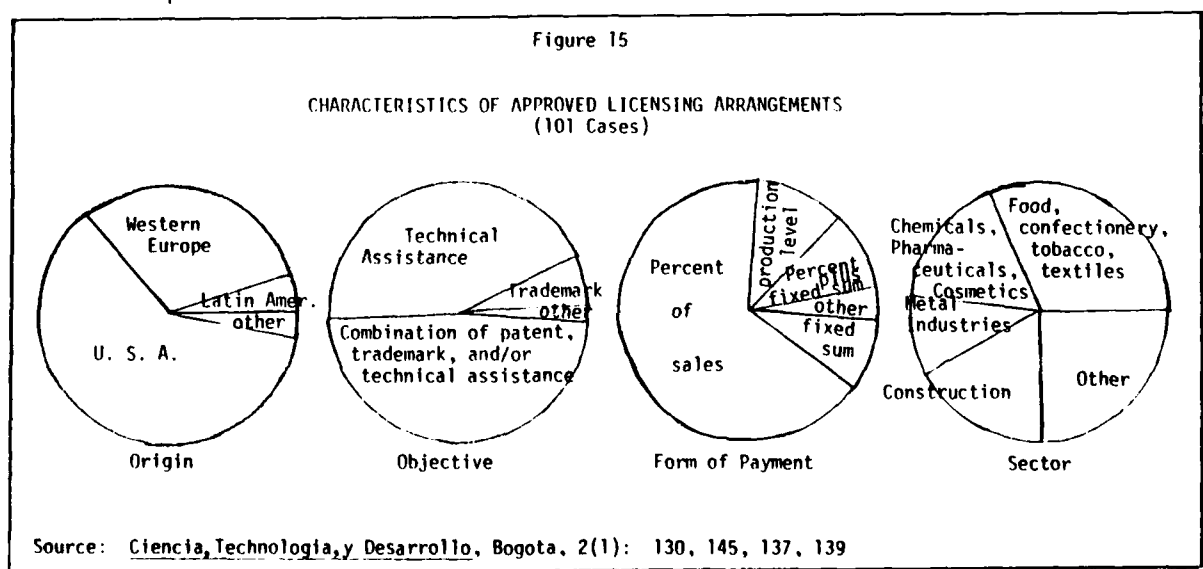


Figure 16

REASONS FOR LICENSING DENIALS

<u>Reason</u>	<u>No. of Denials</u>
Similar production in Colombia without royalties	101
Technology already assimilated in Colombia	53
Negative effect on balance of payments	87
Excessive payment relative to national benefits	30
Other	72

Source: Ciencia, Tecnologia, y Desarrollo, Bogota, 2 (1): 142, February-March, 1978

Many suggestions have been offered as to steps that could be taken to accelerate the flow of technology from abroad and at the same time strengthen local technological capabilities. Figure 17 presents a series of recommendations in this regard from a June 1979 seminar involving U.S. and Colombian business interests.

Figure 17: VIEWS OF BUSINESS COMMUNITY ON TECHNOLOGY TRANSFER

<u>GOALS</u>	<u>OBSTACLES</u>	<u>PROPOSALS</u>
Increase local content: .labor .raw materials	Incentives - payment between parent and subsidiary	New incentives: .capitalize technology .flexible payment methods
Control of S and T	Competition	New institutions and policies linking private and public sectors
Reduce costs: .social .economic	Restrictive practices of suppliers	Coordinate policies to facilitate transfer of technology: .increase contract terms .combine technology/know-how .clarify approval criteria .value of trademarks and of corporate experience
Develop small and medium firms	Access to know-how	
Improve value of technology	Enterprise capacity to absorb technology	
Exports	Manpower	
Manpower development	Active user community	
Local R and D	Risk	Support training administrative production innovation
Diversify local industry: .products .location	Linkage (gov't. - S and T productive sectors)	Stimulate long-term JVs
Promotion of non-traditional products	University link to business	Regional cooperation
Regional cooperation	Access to foreign markets	Develop general/flexible criteria
	Developed country constraints	Involve private sector in gov't. technical assistance
	Bureaucratic practices/procedures: .time .cost .flexibility	Small and medium industry support
	Clarity of regulations	Information supply and use - brokerage function
	Regional agreements	Fund joint industry - academic programs
		Include institution involvement in technology contracts
		Direct state enterprise toward national S and T

Source: Business-Government Seminar on Transfer of Technology;
June 4-5, 1979, Bogota. Fund for Multinational Management
Education.

Capabilities of the Private Sector

The exploration and development activities of the U.S. oil and mineral companies operating in Colombia (e.g., Exxon, Texaco, Hanna) involve expenditures of a different order of magnitude than all the other research and development expenditures in the country combined (i.e., hundreds of millions of dollars vs. tens of millions annually). Given the significant number of high quality Colombian technical personnel employed by these companies and by the Government and quasi-Government organizations (e.g., ECOPETROL) working with the companies, the technological know-how transferred through these activities should be very substantial. Consideration should be given to how the Colombian universities and other technical institutions can relate more effectively to these activities in the area of the country where they are underway. For example, should Exxon expand activities on the north coast, opportunities for company interactions with universities and technical schools in Baranquilla should be explored.

A second area of technological activity that is frequently overlooked is the extensive exploration and engineering work associated with large Government development projects, and particularly those involving dams, roads, electrical systems, and communication networks. Much of the engineering and construction work is still carried out by international firms although Colombia has developed a significant capability in these areas during the past several decades, particularly with regard to construction activities. While the standards and the basic technologies involved have been developed abroad, still substantial adaptations are frequently required. For example, foundations must be adapted to soil conditions, the properties of local materials used in construction activities must be carefully considered, and allowances must be made for maintenance or other problems that may be encountered after a system is operational. Several Colombian engineering consulting firms are particularly strong in civil, electrical, and mechanical engineering, and they can handle such problems with little difficulty.

A recent survey of 100 large and medium manufacturing firms in Colombia indicates an average expenditure of 0.5 percent of sales on design engineering and product modification activities. This survey also reports a correlation of increased productivity with such expenditures, allowing for an appropriate time delay. Indeed, at most firms the capabilities of the engineers have become a very important determinant as to the types of technologies that are employed and the degree to which innovations are considered by management. Frequently, these firms have formal or informal ties with engineering staffs abroad which in many cases are used simply to review local technical judgements and thereby add an important confidence factor. At the same time, some firms show little interest in technical change since as long as they enjoy a protected market there is little financial incentive to innovate.

About a dozen locally owned firms operate research laboratories. Most of the activities could best be described as adaptive research (e.g., paint deterioration at high altitudes), but some reflect entry into new fields (e.g., ore beneficiation). In several cases these laboratories reflect an upgrading of facilities that had previously been devoted to quality control, and of course there are many additional quality control laboratories. However, research as a concept has not been generally accepted by the industry. One research director urged that his activity not be referred to as "research" lest his management terminate financial support for his operation. One serious inhibition to the funding of research is the current rate of inflation. Since research is in large measure an investment in the future, it is difficult for investments in research to compete with financial investments which return 30 percent interest.

Some of the multinational firms have good laboratory facilities in Colombia. The Dow facility, for example, is concerned largely with new uses of plastic products and to this end assists potential customers in determining the suitability of plastics for a variety of applications. The Chrysler facility is a sophisticated motor vehicle quality control and testing laboratory. A major task is to help upgrade the technology capabilities of the suppliers of vehicle components, and this facility provides a good base for that mission. However, in general the research carried out by the multinational firms is limited in scope with significant activities concentrated in facilities in the United States. IBM has contributed a computer to the SER Research Institute and is providing advice on systems analysis techniques. This type of capability is clearly needed in the country, and the Institute is directing its new capabilities to the analysis of national manpower requirements in response to Governmental requests.

Two important research facilities are supported in whole or in part by the private sector. The Coffee Research Institute, which has a chemical analysis facility in Bogota as well as its agricultural-oriented activity in Cali, and the recently established Sugar Research Institute enable Colombia to stay abreast of world-wide developments that could affect important agriculture products as well as to identify opportunities to increase the production and utilization of these crops. This type of research on natural products of considerable importance to the nation should be strongly encouraged.

The Role of Government Research Institutes

As a result of substantial investments by the Colombian Government and a number of international agencies during the past two decades, the Institute for Technological Research (IIT) is one of the best equipped Government research facilities in Latin America. This institute provides a valuable function for the Colombian Government as a principal resource for keeping abreast of technological developments in the industrial field. Also, it has been assigned significant responsibilities in providing information and advisory services to industry, and particularly small industry. At the same time, however, there have been unrealistic expectations as to the likelihood that such an institute would be able to develop new products and processes which would have a major impact on the commercial activities and interests of the private sector. Even in the development of new food technologies, which are usually cited as the institute's principal success stories, there is some question as to whether such activities really stimulated industry or were simply carried on in parallel with comparable industrial efforts.

Other Government research institutes exist in the fields of marine sciences, natural resources, and cement. Also a new research institution has just been established in the area of forestry which will probably be a public sector undertaking. In these areas, the coupling of research activities with production interests should be easier than in the area of manufacturing. The Government plays a substantial role in the development of the nation's resources and is the principal customer for the cement industry. In all of these areas, there are many opportunities to link research activities with the interests of the universities through student, faculty, and researcher exchange arrangements.

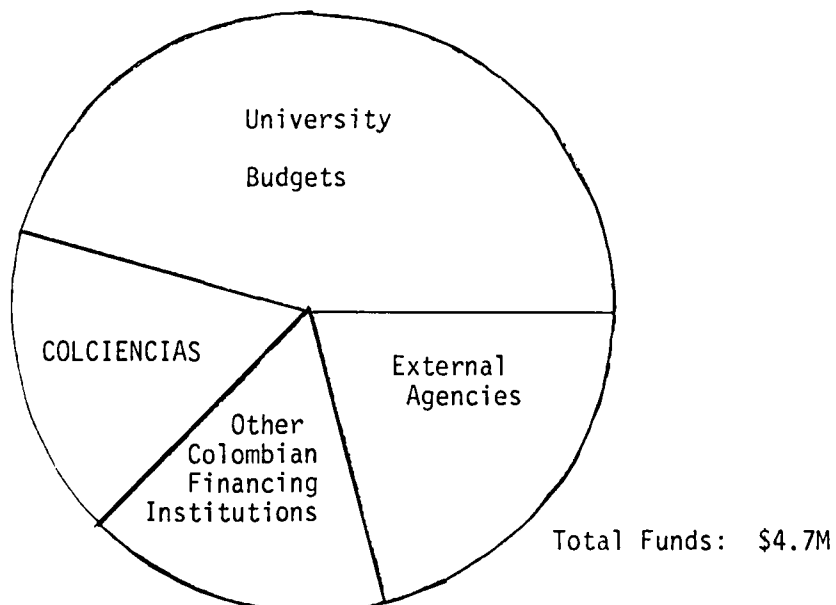
Several Government agencies have specialized technology and quality control laboratories. ECOPEPETROL operates one scientific and three engineering laboratories. ECOMINAS, the national mining company, operates two laboratories, and the Ministry of Works has a very small quality control facility. INSCREDIAL, the National Land Credit Institute, has an engineering laboratory directed to building standards and construction techniques.

Research at the Universities

Research expenditures at the universities have grown substantially in recent years although the total support is still only \$5 million per year. Figure 18 indicates the sources of funding. As shown in Figures 19 and 20, over 1,000 investigators are involved in formal research programs at 28 universities. Figure 21 depicts the recent growth of research at the universities by general field of interest. In short, there is a little money, a lot of interest, and an uncertain potential. There are countervailing views which question the payoff from university research and argue that such efforts detract from educational responsibilities of faculty members who are already overloaded with teaching responsibilities. However, the fundamental issue is not whether research is important at the universities, but rather the issues are what type of research and how much.

Figure 18

SOURCES OF UNIVERSITY RESEARCH FUNDS (1977)



Source: Research at Colombian Universities,
COLCIENCIAS, 1978

Figure 19
DISTRIBUTION OF UNIVERSITY RESEARCH FUNDS

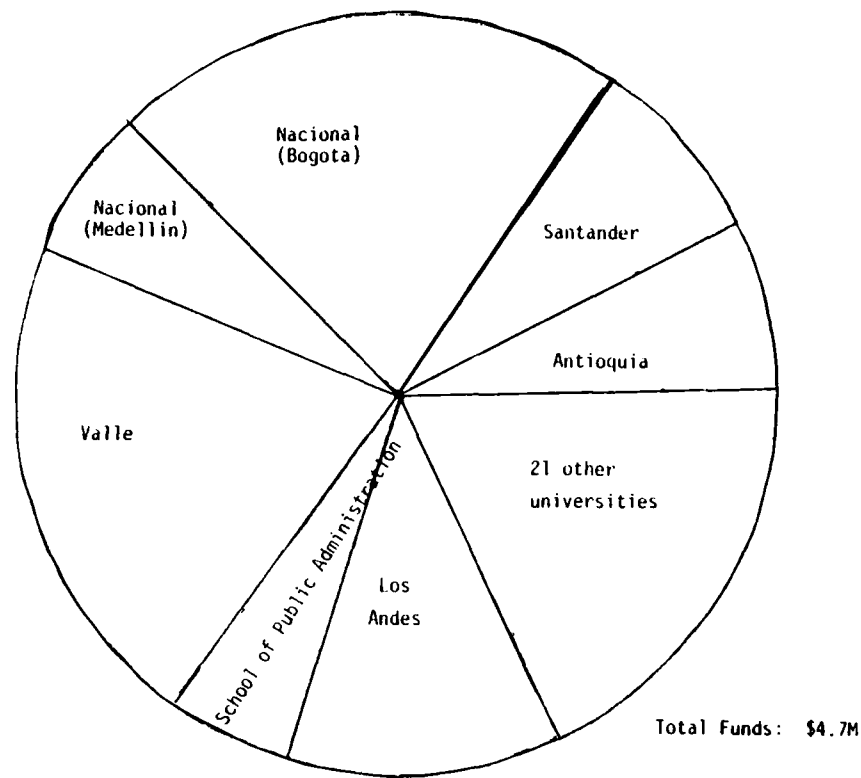
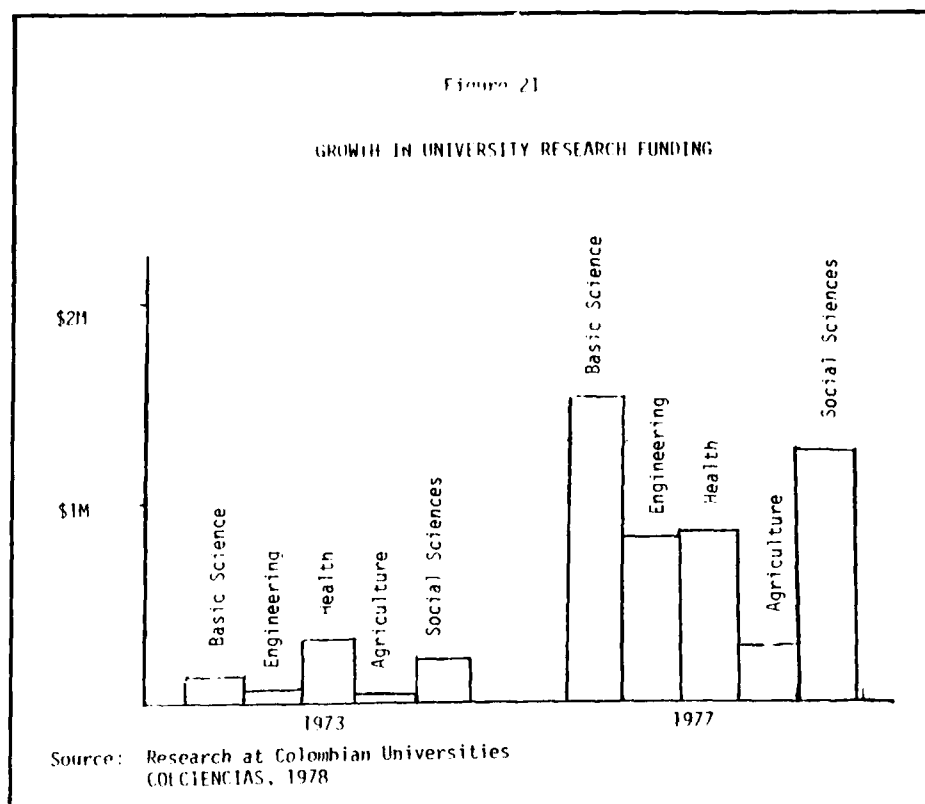


Figure 20
UNIVERSITY RESEARCH : PROJECTS, COSTS INVESTIGATORS
(1977)

	<u>No. of Universities</u>	<u>Projects</u>	<u>Cost</u>	<u>Investigators</u>
Basic Sciences	17	248	\$1.56 M	428
Engineering	14	66	.82	138
Health	9	111	.86	210
Agriculture	10	44	.25	64
Social Sciences	<u>18</u>	<u>137</u>	<u>1.22</u>	<u>215</u>
TOTAL	68	606	\$4.71 M	1055



It is highly unlikely that for the foreseeable future Colombia will be able to carry out research of an international caliber in the basic sciences, i.e., physics and chemistry. Therefore, major research efforts directed to exploring the frontiers of science in these areas seem hardly justifiable. However, there are a number of derivative sciences, and particularly the bio- and geo-sciences, which couple closely to the resource endowments of the country and which should receive considerable attention. Concentration in these areas would in turn help orient the efforts in the more basic sciences to higher payoff areas. For example, research efforts in marine sciences -- one of the derivative sciences -- in turn draws on physics studies of acoustical properties of the sea and on chemistry studies direct to chemical contaminants in coastal areas. Similarly, concentration on geological investigations requires work on the physical properties of the earth and on chemical analyses of geological formations.

With regard to research efforts at the engineering facilities, there have been some unrealistic expectations that such efforts could impact directly on the commercial interests of entrepreneurs in innovation. At present, some of the effort at engineering facilities is being directed to the revival of intermediate technologies. The appropriate technology group Los Gaviotos is in a sense a spinoff organization from the engineering faculty at Los Andes University. There are other important areas of applied technology where the engineering faculties can be helpful to industry. A current example is in pollution control, both in measuring and analyzing levels of pollution near industrial facilities and in designing pollution abatement equipment. The University of Antioquia has major contracts from a local industry in both of these areas. University research in food technology and plastics is also being emphasized, but the commercial payoff is not yet apparent.

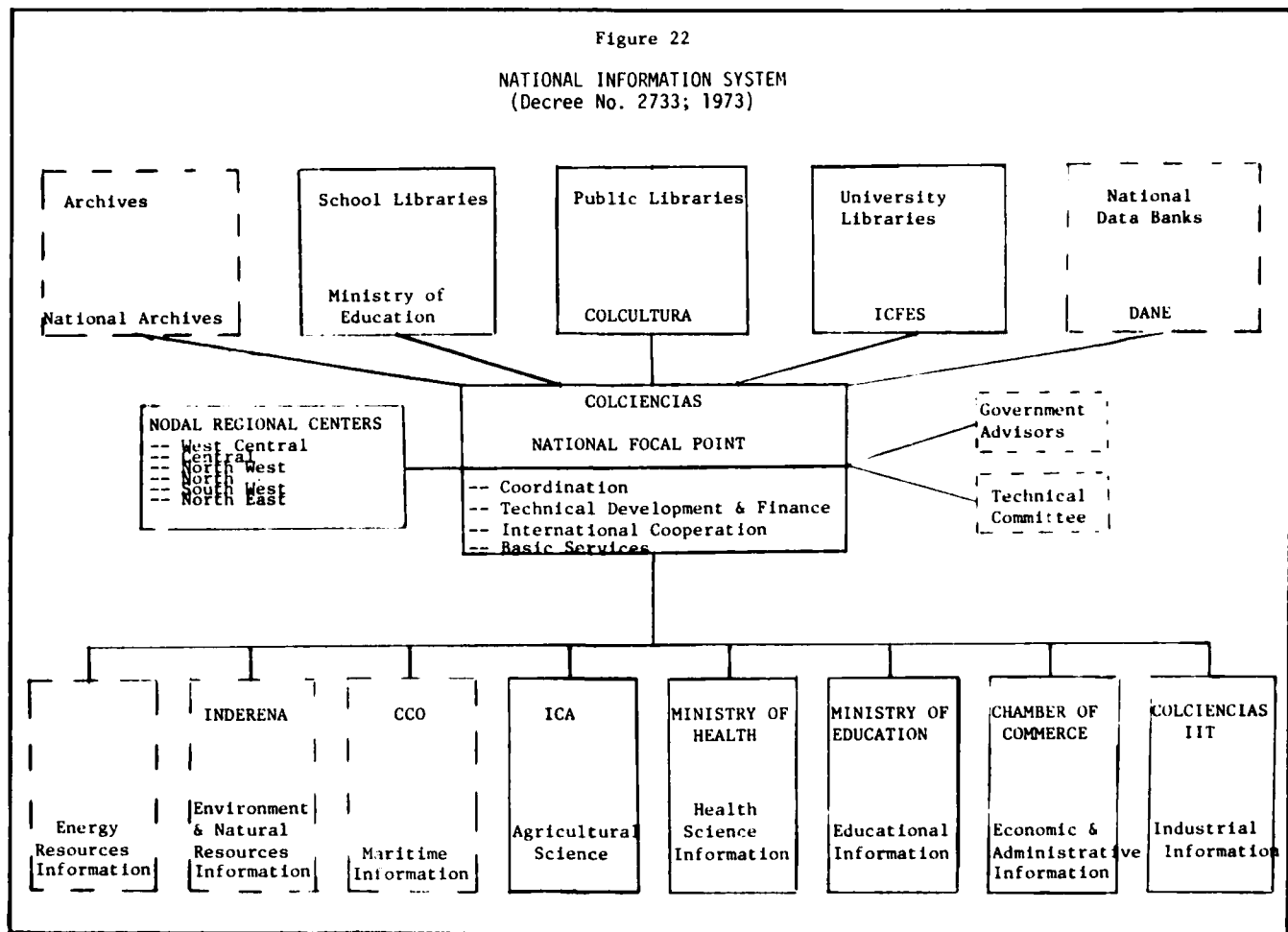
Many of the research projects at the universities are very small and are of short duration. It is not surprising that discernible impacts of such projects are difficult to uncover. Also, such small projects do not serve as effective magnets for attracting and retaining the interest of promising young scientists and engineers who have other employment options. Clustering research activities in larger and longer term programs, which would inevitably mean sharp reductions in the total number of research programs in the absence of major increases in the availability of funds, seems preferable to the current approach of mini-projects scattered throughout the universities.

The perceived lack of payoff to date from university research efforts highlights the need for improved interactions between the universities and the industrial sector in specialized technical areas. In addition to the examples previously cited, there have been other cases of collaborative programs undertaken between universities and industry. For example, Exxon has recently entered into a contract with Los Andes University for assessments of the likely sociological impact of a major program to develop the coal resources along the northeastern coast of the country. Many of the universities have ambitious plans to engage the local industrial communities in a range of activities, and some have established special organizations directed to this end. However, at the present time the number of significant research projects that are of joint interest to both the universities and industry are few. As discussed below, there is a far broader range of interactions in the areas of routine testing and technical advisory services for small industry.

SCIENCE AND TECHNOLOGY SERVICES

Information Systems

For a number of years COLCIENCIAS has attempted to develop an approach to a national information system. The framework for such a system is set forth in Figure 22.



Initially, considerable emphasis was given to the designation of five universities to serve as regional information hubs. Each of these universities was to emphasize a somewhat different set of information priorities oriented to the needs of the particular region. However, this concept did not work very well. Most importantly, universities are not well coupled to production activities in Colombia. Also, the educational information systems of the universities are deficient in many regards and do not provide a strong basis on which to build regional information networks.

The current approach calls for a distinction among information for statistical, educational, and applied production uses. Combinations of Government ministries and appropriate research institutions have been assigned responsibilities in

various sectors. COLCIENCIAS plays largely a coordinating role with very limited funding responsibilities. As would be expected with such a distribution of responsibilities, there are some very good and some very weak aspects in the overall information scene.

One of the weakest links is the information support for private sector manufacturers. Perhaps it is unrealistic for the Government to play a significant role in assisting firms, except the very smallest, obtain the specialized information they need for day-to-day decisions and operations. Most of the larger companies have extensive informal information networks -- domestically and internationally -- and the smaller firms seem more interested in observing rather than reading about improved processes. Still, printed documentation of a somewhat general character has a role to play within almost every firm. Also, the economies of scale argue for some types of information systems that transcend the information systems developed by individual firms.

The Chambers of Commerce and the National Association of Industries (ANDI) are probably in a better position than the Government agencies in keeping abreast of private sector interests in providing timely access to technical information. Greater attention should be given to how these organizations might expand their information activities currently targetted on national economic policies into broader areas and how such activities could relate to Government efforts in the information field.

During the early 1970s both UNESCO and the OAS pressed hard for the establishment of centralized documentation centers throughout the developing countries. While these and other external agencies are now committed to greater emphasis on user-oriented approaches, there still is inadequate attention to the interests and capabilities of the users of information.

With regard to national planning, COLCIENCIAS has gathered and published considerable quantitative information concerning the nation's science and technology base. However, if this information is to be meaningful, evaluative reports are also needed. Perhaps several of the local non-profit study groups could be encouraged to assist in critical analyses of the effectiveness and impact of selected science and technology activities supported by the Government. In addition, COLCIENCIAS publishes an important journal which provides a forum for airing national science and technology issues.

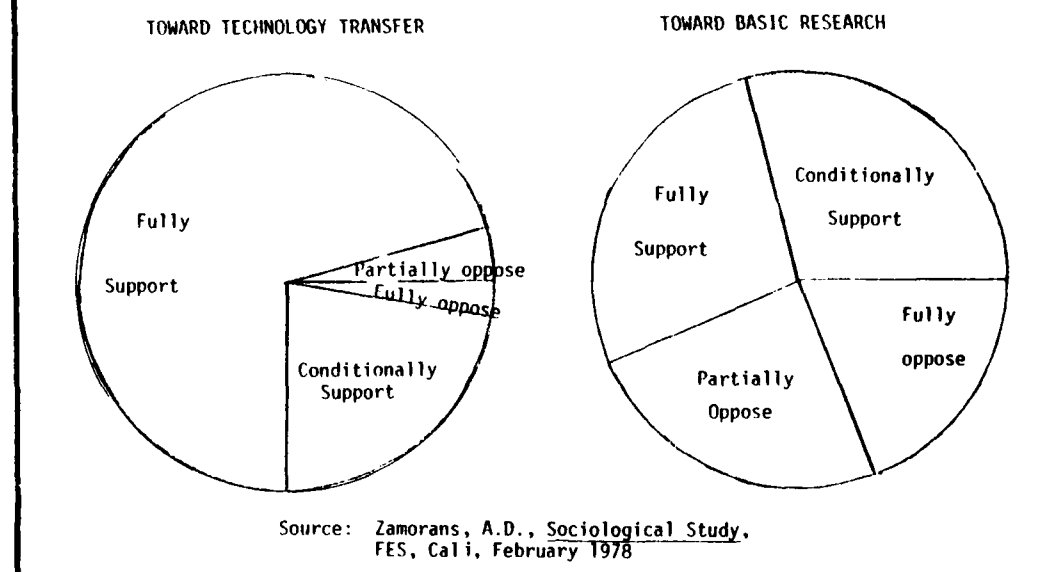
Colombia has a reasonably well developed publishing industry. Many research institutes and universities regularly publish their findings in various journals, but principally journals of the individual institutions. Unfortunately, few publications are in English or contain English summaries. There clearly is a significant language barrier in bringing Colombian achievements into the mainstream of international science and technology.

Direct Assistance to Small Industry

A variety of organizations have programs of assistance for small entrepreneurs. Government agencies, research institutes, financial institutions, private organizations, and external agencies provide a variety of services of varying quality and impact. The lack of coordination among these efforts is striking.

All of the organizations seem to recognize the importance of entrepreneurial attitudes and capabilities in their efforts to upgrade productivity. The sharp orientation of entrepreneurs toward foreign technologies and their skepticism concerning local research efforts are reflected in the attitudes reported in Figure 23.

Figure 23
MANAGERIAL ATTITUDES



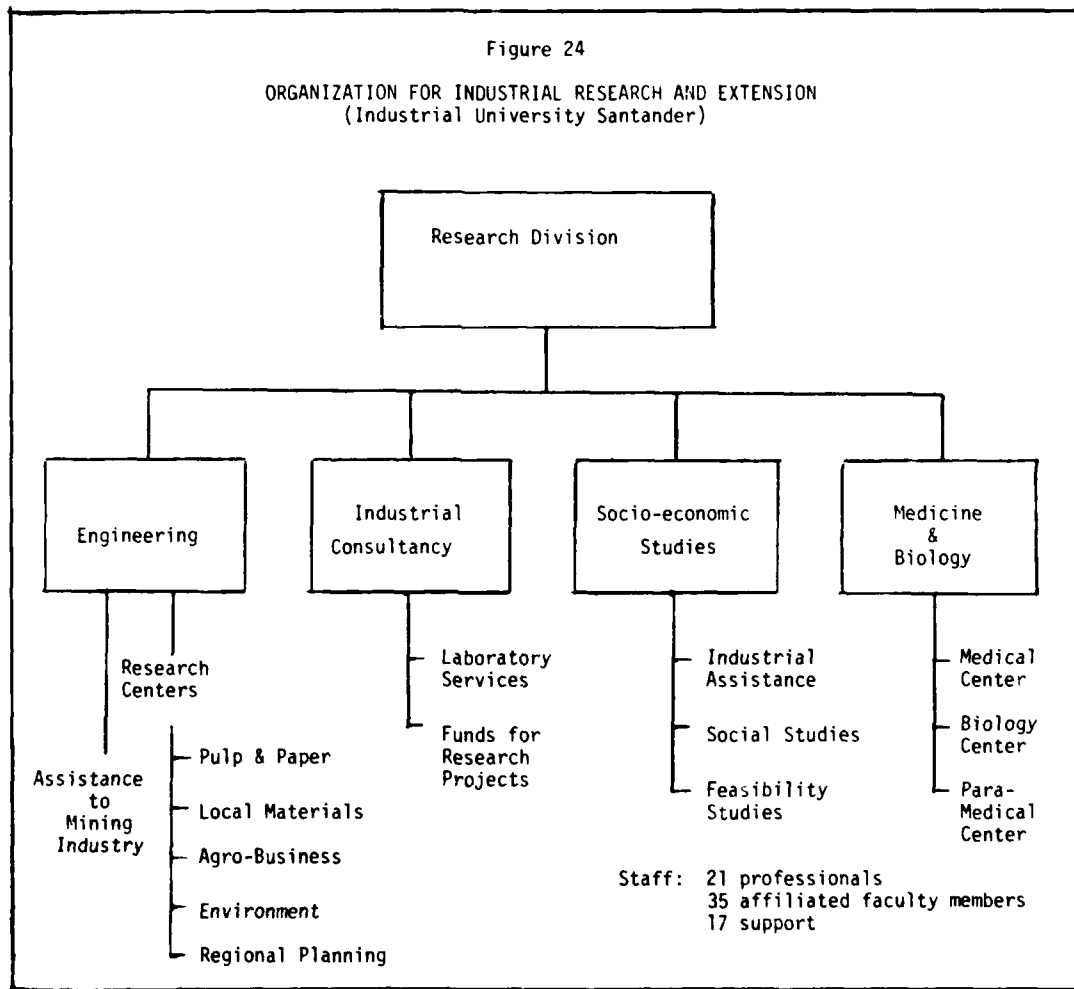
The assistance efforts of three organizations started out as being very well conceived and having considerable potential for high impact.

1. The International Executive Services Corps (IESC) has placed many retired U.S. management and technical experts within a large number of Colombian companies during the past decade. The success of this program is reflected in the financial support received from clients. Now the program requires no external funding. The IESC estimate that more than 80 percent of the experts are well placed and achieve what had been planned is probably realistic. The few failures are probably attributable to (a) personal problems of the experts, and (b) problems in clearly defining the tasks of the experts prior to their recruitment.

2. FICITEC concentrates its efforts on improving managerial performance which, in turn, can lead to increased productivity. FICITEC seems to operate at the cutting edge of modern management theory and carefully integrates its research activities concerning managerial behavior and motivations with high quality assistance programs to its clients.

3. The Popular Finance Corporation (PFC) has an extensive program of technical assistance to the recipients of loans from the organization. These recipients represent about 20 percent of small entrepreneurs in the country. The program was initially funded by AID. Now there is a dual financial approach. PFC provides technical information bulletins on specific production problems and sends experts to requesting firms to help clarify problems and define technical approaches. Secondly, PFC provides loans, at slightly reduced interest rates, for more detailed technical analyses and to help implement technical improvement programs. However, the attractiveness of technical assistance loans does not seem to be high.

Several universities have outreach programs directed to small industry. The excellent testing facilities of Nacional University in Bogota are in high demand among industries of all sizes. At the other extreme, routine concrete testing on relatively simple equipment is commonplace within many civil engineering departments. Perhaps the most ambitious industrial program is at the Santander Industrial University which is described in Figure 24. Still, even with regard to this university, many manufacturers are skeptical of the relevance of university activities to production interests. When university services are free, or nearly free, industry may be a willing partner. When significant costs to industry are involved, industrial interest fades quickly.



The technical assistance programs of SENA have not been as successful as the apprenticeship programs. Recognizing the shortcomings in these activities, SENA has recently reorganized the programs under new leadership. Still the problem of attracting and retaining high quality staff persists.

IIT has an assistance program with a strong technological base. The other Government research institutes similarly provide services for small entrepreneurs.

Supporting Technical Activities

The industrial repair and maintenance capabilities of Colombia do not seem to be a significant impediment in sustaining the current level of technologies being employed. Most of the larger companies have their own maintenance crews while the many small shops in most cities have become quite expert in electrical and mechanical repair work. Spare parts for sophisticated machinery are, of course, often a problem. The few foreign companies with well equipped service representatives in Colombia, such as IBM and Varian, seem to be capitalizing on this support capability in attracting new purchasers of their equipment. COLCIENCIAS might consider a limited survey of maintenance and repair capabilities to determine if there are any easily correctable deficiencies in this area.

Colombia has recognized the importance of industrial standards as the industrial base of the country expands. ICONTEC serves as the focal point within the country for the development of such standards. Many of the multinational firms obviously have an interest in the development of such standards and play an active role in their development. For example, General Electric has spearheaded the effort for the adoption of standards for light bulbs and other electrical products.

Many non-proprietary technologies are in place throughout the country. Also, dispersed within the workforce are experts in almost every area of industrial activity. Many of these experts and other specialists hunger for opportunities to stay abreast of technological developments in their fields. Yet there are few effective mechanisms for facilitating the horizontal dissemination of existing technical capabilities throughout the economy.

Conspicuously absent from the scene are active professional societies at the national level in science and engineering. While there are a few engineering societies, almost all of the significant professional interactions have been among specialists living in small geographical areas. Similarly, the trade associations have not been particularly effective in promoting technical interchanges on a sustained basis. While the approaches of professional societies and trade associations in the United States should be of interest in Colombia, even more imaginative ways for facilitating the diffusion of technology should be explored.

THE FRAMEWORK FOR BILATERAL COOPERATION

As Colombia continues to develop its science and technology base, the opportunities for mutually beneficial cooperation between specialists in the United States and Colombia increase. In most areas of science and technology, Colombian institutions could benefit considerably from the U.S. experience over many years in resolving similar problems while passing through the earlier stages of development. For the United States, benefits from collaborative activities would be measured primarily in economic terms-- through improved opportunities for trade and investment that often follow in the wake of science and technology cooperation. In some areas, such as the earth sciences, the U.S. participants should also derive significant technical benefits.

The Decline in Bilateral Exchanges

Ironically, just as the opportunities for cooperation are on the rise, the U.S. funding mechanisms that have supported the most important programs in the past are being phased out, and particularly the programs of AID and U.S. private foundations. The occasional visitors from the National Bureau of Standards and the National Technical Information Service no longer include Colombia on their itineraries. Even the Peace Corps, which had significant technical programs, is leaving Colombia. The atrophy in bilateral linkages is particularly discernible at the Colombian universities where American scientists and engineers are now rare sights and where attendance at technical meetings in the United States is no longer considered seriously. This lack of interaction is undoubtedly one factor in the decline in emphasis on the English language at universities.

Indeed, the Fulbright Program, which in Colombia is now heavily oriented toward science (see Figure 25), is the last vestige of the many successful exchange programs of the past. As previously noted, the Colombian program of the International Executive Service Corps has become largely self-sustaining, a tribute to the effectiveness of that program in helping to upgrade the technical and managerial skills within Colombian industry. For a few years the cooperative programs involving university researchers supported by the National Science Foundation (NSF) seemed to be emerging as a significant mechanism for promoting cooperative efforts. For example, the Engineering Department of Lehigh University participated in several interesting joint research projects. However, much of the interest in the program seems to have subsided. Similarly, the NSF-administered SEED program, after a successful brief life, has terminated. Thus, the case for more effective funding mechanisms that will attract and retain the interest of high quality specialists in both countries seems clear.

Figure 25

FULBRIGHT PROGRAM (1977)

	<u>Science</u>	<u>Engineering</u>	<u>Other</u>
U.S. University Lecturers	5	1	4
U.S. Students	-	-	5
Colombian Graduate Students	12	7	21

Source: Fulbright Commission, Bogota, June 1979

Over the years AID had been the principal vehicle for the financing of scientific and technical exchanges and other types of cooperative arrangements in the physical and engineering sciences. Such activities had occupied a very secondary position to AID's major efforts in the transfer of financial resources and in the support of institutional development in the educational and agricultural fields. However, in view of the large size of the AID program over a sustained period of 25 years, even the very small portion of the program directed to the physical and engineering sciences supported substantial activities. Of particular importance were the training components often associated with large loan programs. In addition, during the early 1970s Colombia was a test bed for a number of experimental AID projects in science and technology (e.g., use of sulfur bonding in house construction, systems approach to improved planning in the construction industry, modelling as a basis for water resources planning, improving science policy planning mechanisms). Also, at present several AID residual programs address areas of interest, including the use of low-level technologies in rural road construction and technical assistance to small industry through financial institutions. Before all traces of these projects disappear, an evaluation of the strengths and weaknesses of the alternative approaches that were attempted could be helpful in the design of related projects by external agencies. (See Figure 26.)

Figure 26

ILLUSTRATIVE AID-SUPPORTED PROJECTS
(1969-1979)

Bilateral Programs

Technical Assistance to Small Industry
Labor Intensive Rural Road Construction

Popular Finance Corporation
Ministry of Works

Regional Programs (Special OAS Projects)

Technology Transfer Pilot Project
Strengthening Marine Sciences Capability

COLCIENCIAS
Marine Sciences Institute

Central Programs

Sulphur Bonding in Construction
National Science Policy
Systems Approach to Construction
Hydraulic Modelling
Technical Information

Southwest Research Institute
National Academy of Sciences
Arthur D. Little
MIT
National Technical Information
Services
Denver Research Institute
A.T.I.

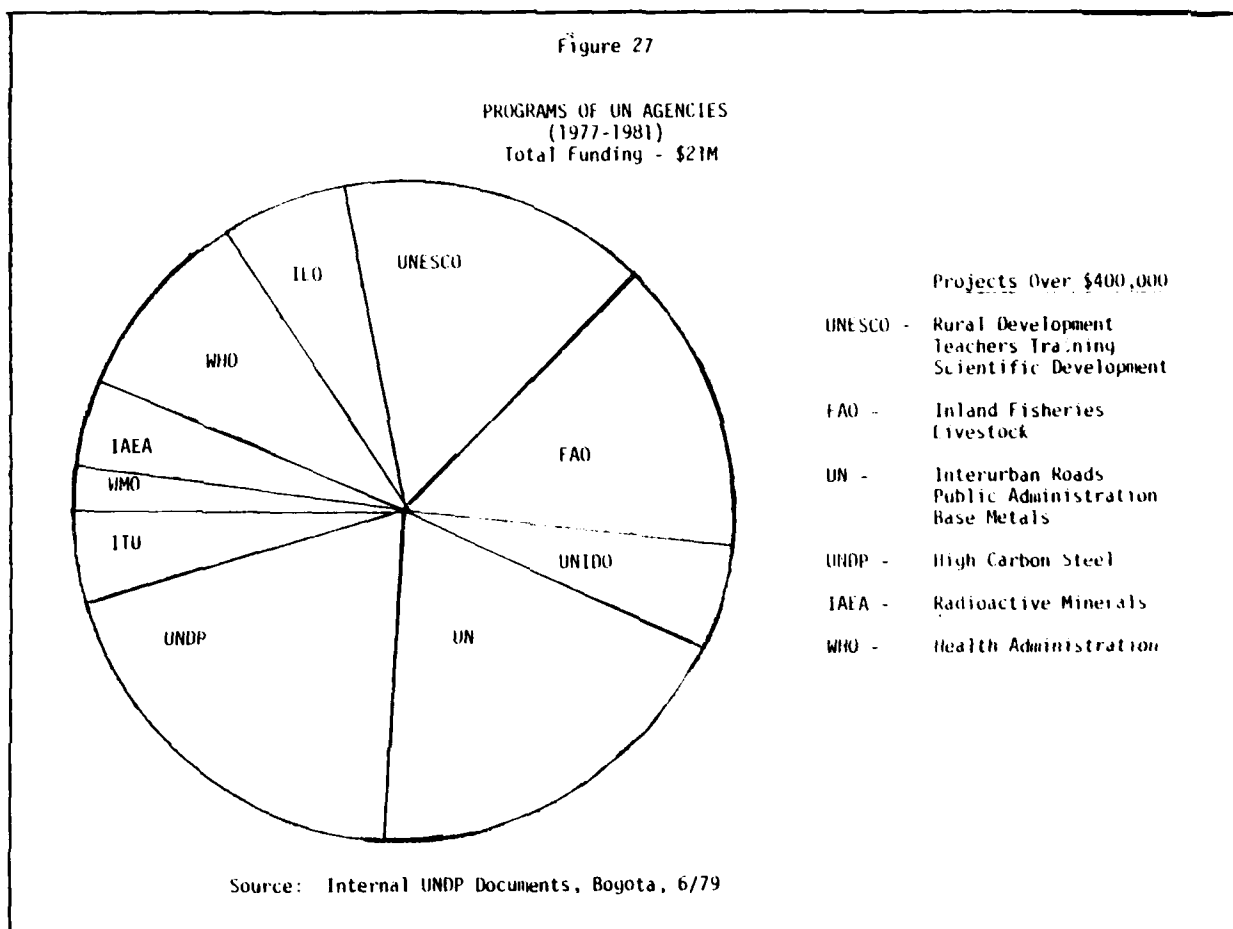
Industrial Research
Appropriate Technology

Interests of the International Development Community

The programs of the World Bank and the Inter-American Development Bank have had considerable impact on industrial development and on the educational system of the country. Large physical infrastructure projects, extensive lending programs of local banks for small industry, and new buildings at several universities can be traced to the activities of the banks. Recently, the banks have added to their portfolios a variety of research programs and deliberately structured technological components of loans. However, information about such activities is not widely available, and specialists in the field of science, technology, and development have difficulty benefitting from the experiences of the banks.

The Organization of American States (OAS) has supported many programs in science and technology in Colombia, particularly research at the universities and Government research institutes. The OAS has worked very closely with COL-CIENCIAS in developing programs not only in Colombia, but throughout Latin America. In view of this extensive involvement in Colombia, the OAS is in a particularly good position to encourage the clustering of research interests at the universities into larger research projects with a greater likelihood of significant payoff.

The UN agencies have traditionally supported many programs in Colombia. Figure 27 describes the current spread of UN agency interests. Among the most important activities for development of the technological base of the country are the efforts of UNESCO to strengthen the training of skilled manpower within the INEM system. U.S. agencies are generally unaware of the activities of the UN agencies.



More projects of the International Development Research Center (IDRC) have been sited in Colombia than in any other country of Latin America, with 50 or so projects funded by IDRC at about \$3 million. About one-fifth of the projects are economic and social science research projects carried out by local institutions to help clarify the role of science and technology in development

activities. However, obtaining the data collected during these projects or even obtaining copies of the research reports in a timely manner does not seem possible.

Finally, many bilateral agencies support programs in Colombia. Among the most impressive activities are the educational and research programs at the Photointerpretation Center in Bogota which for some supported by the Dutch Government.

The Future of Bilateral Linkages

Clearly, many Colombian students will continue to study in the United States. Some will receive support from the Colombian Government, others from U.S. universities, and the bulk from private sources. They will probably continue to cluster in New England and California although individual students will touch many schools in almost every state. Colombians are quite sophisticated in choosing appropriate U.S. institutions of higher education although they occasionally have difficulty in locating the appropriate graduate school for narrowly defined research interests. Additional U.S. Government programs to encourage or guide studies of Colombians in the United States do not appear necessary.

What is sorely needed is a mechanism for supporting U.S. specialists who are invited to spend short periods of time (1-3 months) and longer visits (1-2 years) at universities and research institutions in Colombia. Related support for survey teams and occasional workshops in Colombia would also be useful. In addition, support for attendance by Colombian specialists at conferences in the United States and for sabbaticals at U. S. universities by Colombian academics could be very important in reducing the current isolation which surrounds research and educational activities in Colombia. Finally, U.S. Government support for a few sustained linkages between Colombian institutions and U.S. universities in fields such as petroleum engineering, mining, technology, food sciences, forestry, and oceanography could be of substantial interest and benefit to both countries.

The recently proposed Institute for Scientific and Technological Cooperation was originally conceived largely as a vehicle for fostering cooperation with the advanced developing countries. However, given the planned strong emphasis on research on global problems, the number of bilateral programs that it will support will be very limited.

The experience of the Fulbright program in Colombia should be carefully reviewed as a possible model for facilitating exchanges. The IDRC, which has been suggested as a possible model, offers less attractive opportunities. IDRC's emphasis on funding local research activities with minimal involvement of foreign specialists does not offer a good model for facilitating the transfer of technical skills.

Both the U.S. and Colombian Governments should encourage multinational firms operating in Colombia to give greater attention to the opportunities for carrying out innovative activities locally and for expanded interactions with

local educational, research, and technical institutions. The 1973 recommendations of the National Academy of Sciences summarized in Figure 28 identify a variety of approaches that might be considered by these firms in the further development of their activities in the country.

Figure 28

NAS RECOMMENDATIONS FOR ACTIONS BY MNCs - 1973

1. Assign R, D, and E management personnel to selected LDC affiliates.
2. Train selected management personnel in economic and technological development.
3. Provide support from parent company to affiliates in exploring R, D, and E opportunities and linkages with S & T institutions.
4. Expand training programs to include trainees beyond company requirements.
5. Provide career opportunities for graduates of LDC universities that are comparable to opportunities for graduates of U.S. universities.
6. Combine product-design and product-engineering functions in LDCs.
7. Expand search for labor-intensive equipment.
8. Reduce number and variety of product options to ease maintenance problems.
9. Ease performance standards whenever appropriate.
10. Increase use of locally available materials.
11. Eliminate expensive packaging.
12. *Increase subcontracting of production processes.*
13. Use LDC technical and service capabilities to extent possible.
14. Use LDC universities as service consultants and as contractors for research.
15. Encourage and support local professional societies.
16. Refer interdisciplinary problems to LDC institutions.
17. *Provide management internships for personnel from LDC research institutes.*
18. Upgrade capabilities of suppliers to meet high standards of quality control and increase plant efficiency.
19. Experiment with pilot projects at LDC institutions and document and distribute results of experiment.
20. Participate in public service activities, in cooperation with universities and government, in areas such as unemployment, urban congestion, and rural stagnation.

Finally, technical workshops which bring together specialists from the United States and Colombia can be helpful in sorting priorities, avoiding blind alleys, and identifying science and technology activities of high payoff. A very modest workshop involving the National Academy of Sciences about ten years ago was a significant factor in the decision to develop the program of Colciencias.

TECHNICAL INSTITUTIONS
(Selected Observations)

APPENDIX A

	Facilities & Program	Linkages	Other
University of Medellin	Labs inadequate with low-level simple equipment.	Minimal industrial contacts limited largely to routine concrete testing.	No research. 35% faculty turnover each year. ICFES controls enrollment. High quality students.
University of the Valley	Facilities overcrowded. Lose most experienced faculty to industry.	No tradition of cooperation with industry. Occasional contracts. Assistance to small industry activities have spun off.	High quality students, but standards are declining. Graduates find jobs. Many research grants from Colombian and external agencies.
Pontificia Bolivariana University	Good mechanical and electrical engineering labs. Dow and NCR have donated equipment. Airport noise highly disruptive. High academic standards.	Students employed by industry in summer. Collaboration with industry on pollution.	Entering students have weak preparation. New R&D unit attempting to expand research. Engineering graduates find jobs.
Antioquia University	New buildings. Good chemical engineering and pollution equipment.	Large contracts with local liquor company.	Some engineering graduates can't find jobs. Student quotas based on availability of facilities.
Santander Industrial University	Generally good facilities and particularly in chemical engineering. Large numbers of Ph.D.s from US schools.	Extensive linkages through special liaison center for industry.	Most faculty are full-time. 40% of engineering students graduate. Graduates find jobs.
Cartagena University	Limited space. Inadequate labs. New computer. Dynamic leadership.	Industrial contacts spotty. University capability does not meet industry needs.	Some engineering graduates do not find jobs.
Los Andes University	Good hydraulic lab. Other labs not adequate. Faculty turnover reaches 40% a year in some fields.	Invite guest speakers from industry. Seeking endowed chair from industry.	Engineering graduates find jobs. Appropriate technology group has spun off. Seeking additional research support.
Pontificia Javeriana University	Small but good facilities. Inadequate for number of students. Faculty is young and enthusiastic. Good collection of journals.	Difficult to obtain industrial funds. Interested in working with computer firms.	All graduates find jobs. Few funds for travel.
Colombian School of Engineering	Small but good labs. Mostly part-time lecturers.	Bavaria beer company donated land. School hopes to work with high-technology firms.	COLCIENCIAS provides modest research support and considers school a success.
Nacional University (Bogota)	Best facilities in country. Attracts good faculty. Faculty annual turnover rate 20%.	Due to political unrest, industry hesitates to use university capability.	Most graduates find jobs. 20% of faculty involved in some type of research or testing activities. Many students leave because of student unrest.
SENA Training Center (Barranquilla)	Large, modern, and well-maintained facilities. Labs well utilized.	Good relations with large industry. Difficulties with small industry.	Most graduates find jobs. Considerable foreign aid.
Inversiones Mundial S.A. R&D Unit	Very small. Impressive concept and creative energy of managers. R&D limited by facilities.	No interaction with universities.	Lack of incentive for company management to support R&D.
Ministry of Works, Materials Testing Laboratory	Small facility with relatively simple equipment.	Interacts with local universities in hiring and in presenting lectures.	Trains own employees. Some research on properties of Colombian soils.
INTEGRAL Consulting Engineers	Highly experienced and well trained staff. Shortage of good experienced engineers.	Work closely with Government on variety of projects. No interactions with industry.	Conduct research on soils and publish reports.
Dow Chemical R&D Laboratory	Good facilities. Emphasize adaptive research. Good technical staff.	Provide guest lecturers for universities. Hire students for summer employment. Extensive interactions with customers.	
Chrysler Product Engineering Laboratory	Excellent facilities. Most effort directed to product testing. Good staff.	Contract work for ICONTEC. Considerable interaction with suppliers.	

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